WEINRERS

FM-201
NOAA 7/C

ADVANCED VERY HIGH RESOLUTION RADIOMETER (MOD. 2)

AVHRR

FOR THE

TIROS "N" SPACECRAFT

ALIGNMENT AND CALIBRATION DATA BOOK

AVHRR/2

PROTOFLIGHT MODEL (PFM)

FM-201

NOAA-C/7

ITT Aerospace/Optical Division

Fort Wayne, Indiana 46803

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract NAS 5-23400

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1-1
	1.1 Purpose	1-1
	1.2 Applicable Documents	1-1
2.0	AVHRR/2 ALIGNMENT DATA	2-1
	2.1 Scan Plane Alignment	2-1
	2.2 Sync Pickup Position	2-2
	2.3 Alignment/Mounting	2-3
3.0	AVHRR/2 CALIBRATION DATA	3-1
	3.1 Visible Channels Calibration (CH 1, 2)	3-1
	3.2 I.R. Channels Calibration (CH 3, 4, 5)	3-1
	3.3 Telemetry Calibration	3-1
	3.4 Spectral Calibration	3-21
	3.5 I.F.O.V. Characteristics	3-21
	3.6 Channel Registration	3-21
	3.7 M.T.F. Data	3-21
4.0	FINAL BENCH CHECK DATA	4-1
	4.1 Scan Plane Alignment	4-1
	4.2 Visible CH Calibration (CH 1, 2)	4.2
	4.3 I.R. CH Calibration (CH 3, 4, 5)	4-1
	4.4 Spectral Calibration	4-11
	4.5 I.F.O.V. Characteristics	4-11
	4.6 M.T.F. Data	4-11
5.0	MAGNETIC TAPE DATA	5-1
	5.1 Format - Data	5-1
	5.2 Magnetic Tape Listing	5-3

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide calibration and alignment data sufficient for independent verification of instrument calibration and to provide alignment data sufficient for alignment of the AVHRR/2 PFM on the spacecraft.

This document contains data on alignment and calibrations and includes portions of completed test procedures and references of the magnetic tape records of radiance calibrations. The data presented in this book has been reduced from the individual test procedures (appendices). The basis for testing is the AVHRR PFM Test Plan which outlines the test program.

1.2 Applicable Documents

1.2.1 NASA

GSFC S-726-5 and amendments - Specification for an Advanced Very High Resolution Radiometer Mod. 2 (AVHRR/2)

1.2.2 ITT

8125963	Alignment Procedure - Channel Registration and Focus
8125973	Alignment Procedure - Scan Plane
8120260	Calibration Procedure - Radiance Calibration and Noise Meas. CH 1 & 2
8125968	Calibration Procedure - Radiance Calibration and Noise Meas. CH 3, 4 & 5
8125979	Test Procedure - Spectral Response
8125965	Test Procedure - IFOV Response Contours
8125975	Test Procedure - MTF
8125969	Alignment/Mount
8123474	System Test Plan AVHRR/2 (PFM)
8125964	IFOV Registration Check
	AVHRR Technical Description

2.0 AVHRR/2 ALIGNMENT DATA

In this section data relating to PFM Scan Plane alignment and sync pickup position are presented. Only final measured data are presented. Detailed test data along with supporting information is presented in Section 4.0 of this report.

2.1 Scan Plane Alignment

The scan plane alignment on the PFM AVHRR was checked using the Channel 1 field stop and alignment cube. The method is detailed in Procedure 8125973 and essentially measures the angular difference between the location of the Channel 1 field aperture and a reticle image autocollimated off of one face of the alignment cube. This is done in two planes to give the alignment in two orthogonal directions. Figures 2.1-1 and 2.1-2 show the measured angles.

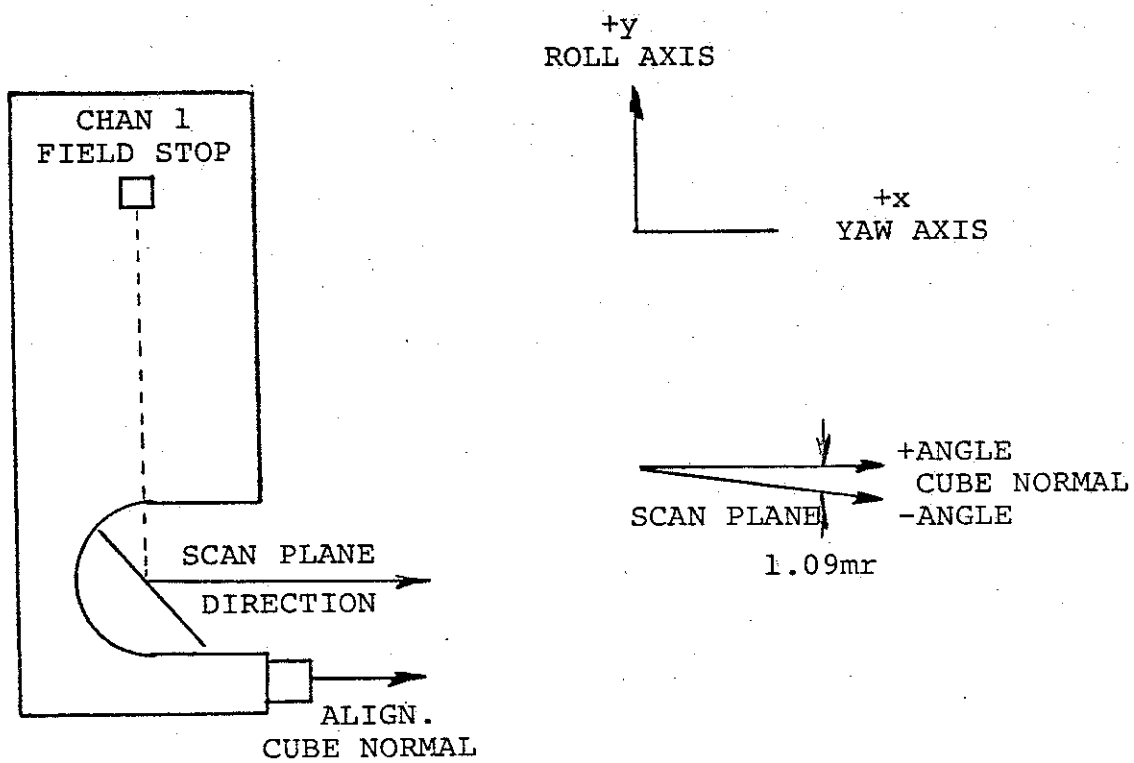


FIGURE 2.1-1 MEASUREMENTS AT NADIR (PFM)

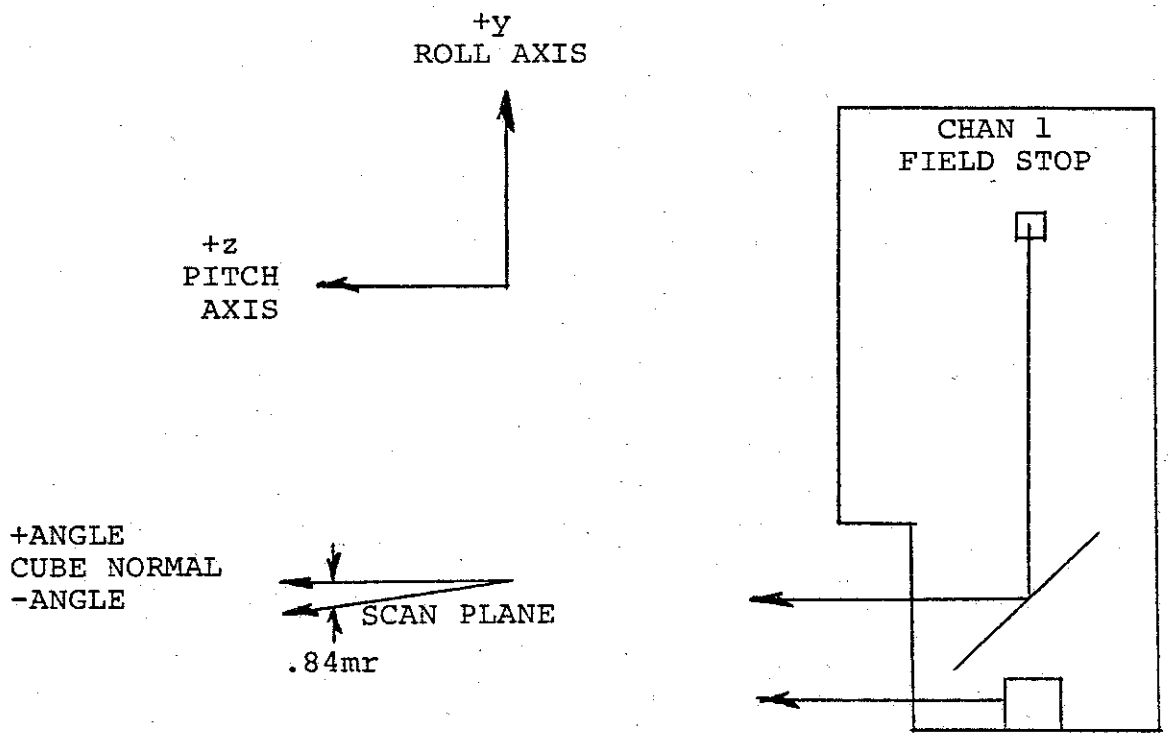


FIGURE 2.1-2 MEASUREMENTS AT 90° OFF NADIR (PFM)

2.2 Sync Pickup Positon

The sync pulse position with reference to Nadir is adjusted and measured. Nadir is defined as the Nadir face of the alignment cube. The measurement is made from the sync pickup signal to an output from Channel 2 with the instrument viewing a scene in the collimator which has been boresighted to the Nadir face of cube.

Sync to Nadir = 34.236 ms for (PFM)

2.3 Alignment Mounting

This measurement is accomplished as detailed in Procedure 8125969. These angles are measured:

1. Scan Plane to Mounting Plane
2. Scan Plane to Mounting Hole Pattern
3. Nadir to Mounting Plane

For each measurement an illustration of the angle to be measured is shown in Figure 2.3.1, 2.3.2 and 2.3.3, respectively. The sign convention is shown in Figure 2.3.4.

2.3.1 Scan Plane to Mounting Plane Angle

Vertical Deflection of Reflected Reticle	=	-20	DIV
Reticle Division X 0.08 Mr/Div	=	- 1.6	MR
Angular Separation from 8120252	=	- 1.04	MR
TOTAL	=	- 2.64	MR

NOTE: This total value must be algebraically subtracted from 90° to obtain the angle shown in Figure 2.3.1.

2.3.2 Scan Plane to Mounting Hole Pattern Angle

Vertical Deflection of Reflected Reticle	=	-20	DIV
Reticle Division X 0.08 Mr/Div	=	- 1.6	MR
Angular Separation from 8120252	=	- .84	MR
TOTAL	=	- 2.44	MR

NOTE: This total value must be algebraically subtracted from 90° to obtain the angle shown in Figure 2.3.2.

2.3.3 Nadir to Mounting Plane Angle

Horizontal Deflection of Reflected Reticle = +2 DIV

Reticle Divisions X 0.08 Mr/Div = + .16 MR

NOTE: This value must be algebraically subtracted from 90° to obtain Angle "A" shown in Figure 2.3.3.

Verticle Deflection of Reflected Reticle = -20 DIV

Reticle Divisions X 0.08 Mr/Div = - 1.6 MR

NOTE: This value must be algebraically subtracted from 90° to obtain Angle "B shown in Figure 2.3.3.

SIGN CONVENTION ON AUTO COLLIMATING

EYE PIECE RETICLE

FIGURE 2.3.4

2.3.3 Nadir to Mounting Plane Angle

Horizontal deflection of reflected reticle = +2 DIV

Reticle divisions x 0.08 Mr/Div = +.16 MR

NOTE: This value must be algebrically subtracted from 90° to obtain Angle "A" shown in Figure 2.3.3.

Verticle deflection of reflected reticle = -20 DIV

Reticle divisions x 0.08 Mr/Div = -1.6 MR

NOTE: This value must be algebrically subtracted from 90° to obtain Angle "B" shown in Figure 2.3.3.

SIGN CONVENTION ON AUTO COLLIMATING

EYE PIECE RETICLE

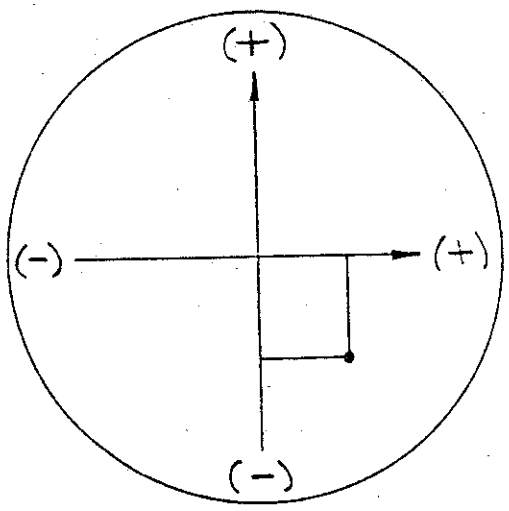


FIGURE 2.3.4

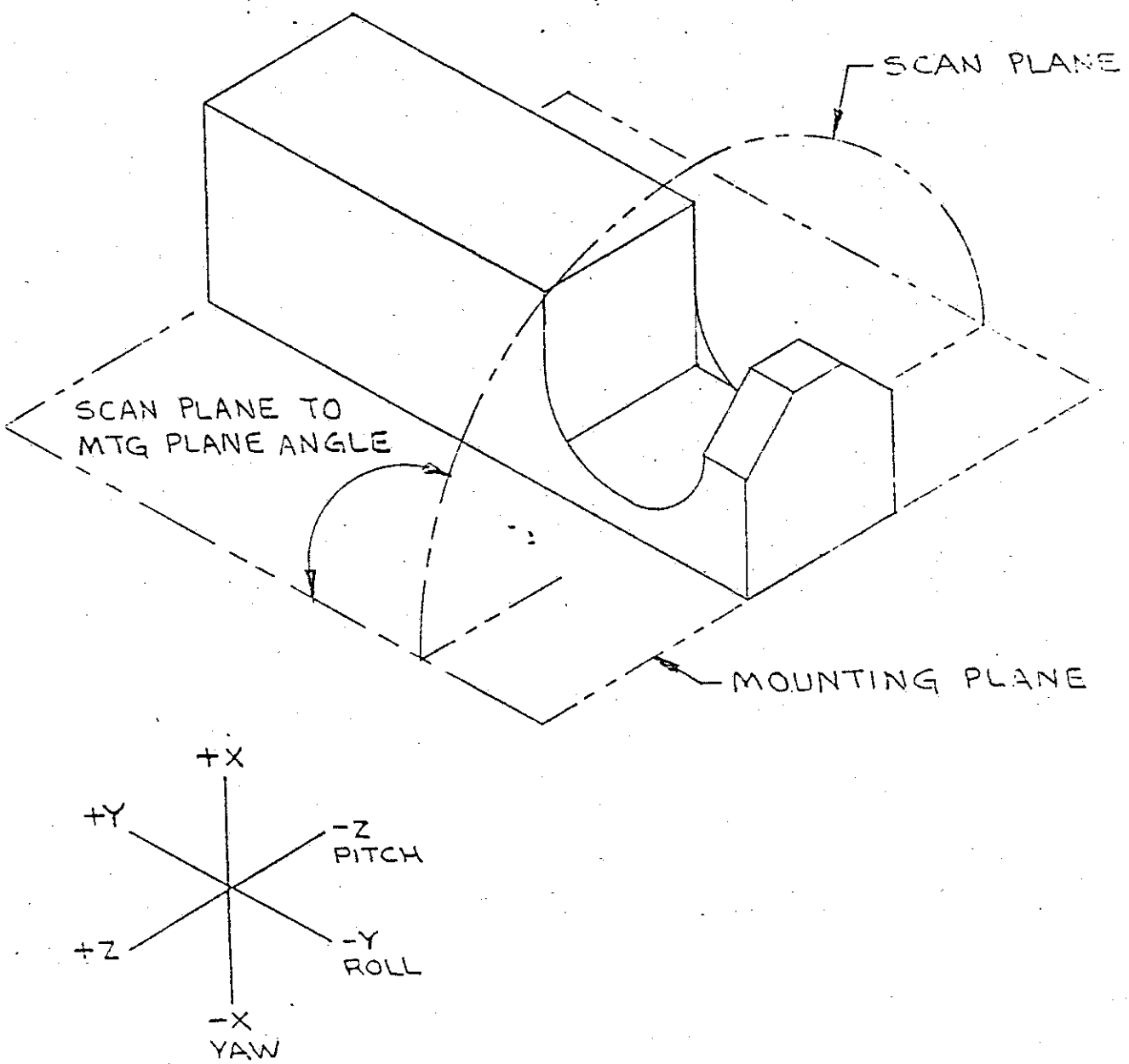


FIGURE 2.3.1

SCAN PLANE TO MOUNTING PLANE ANGLE

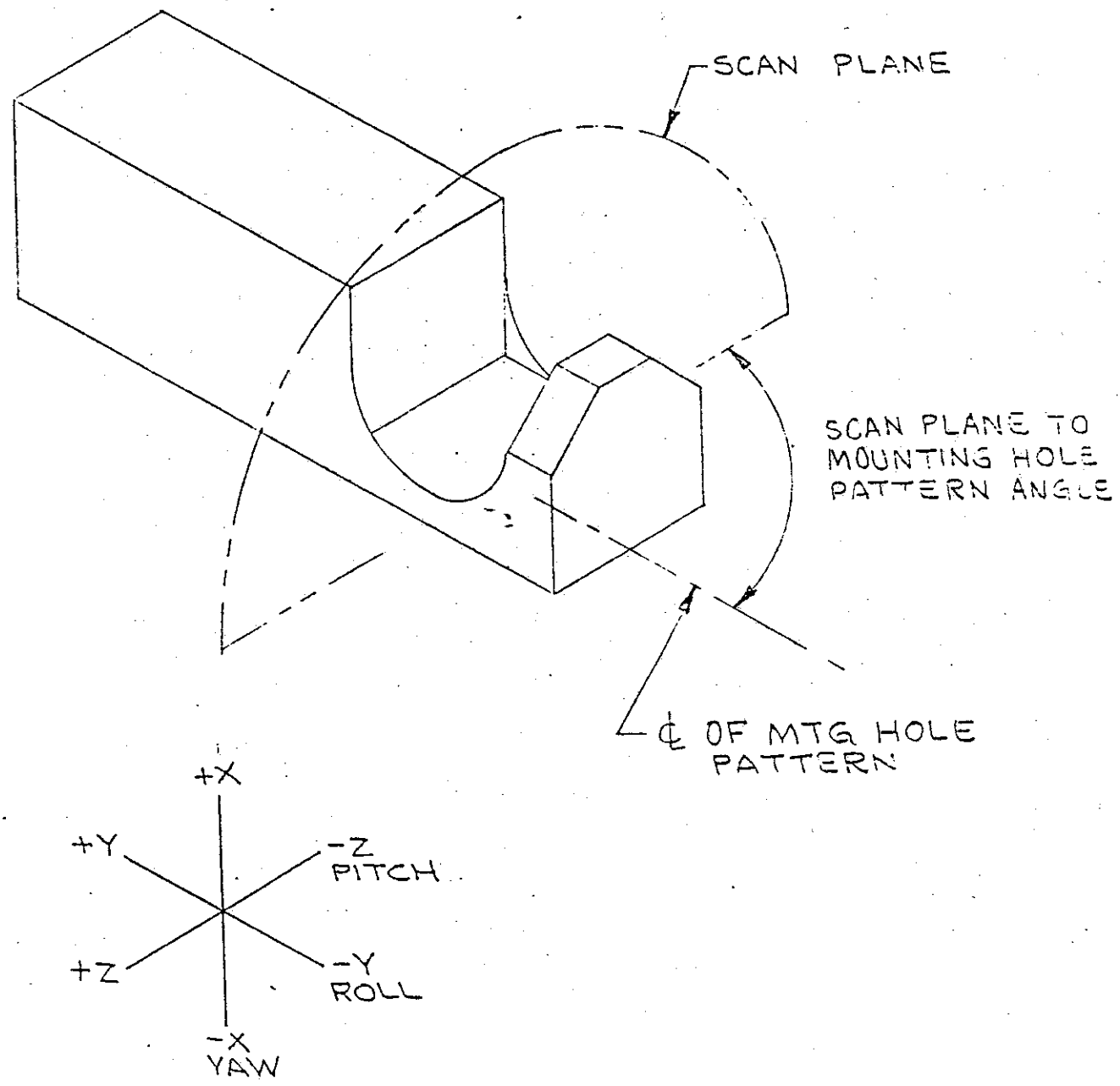
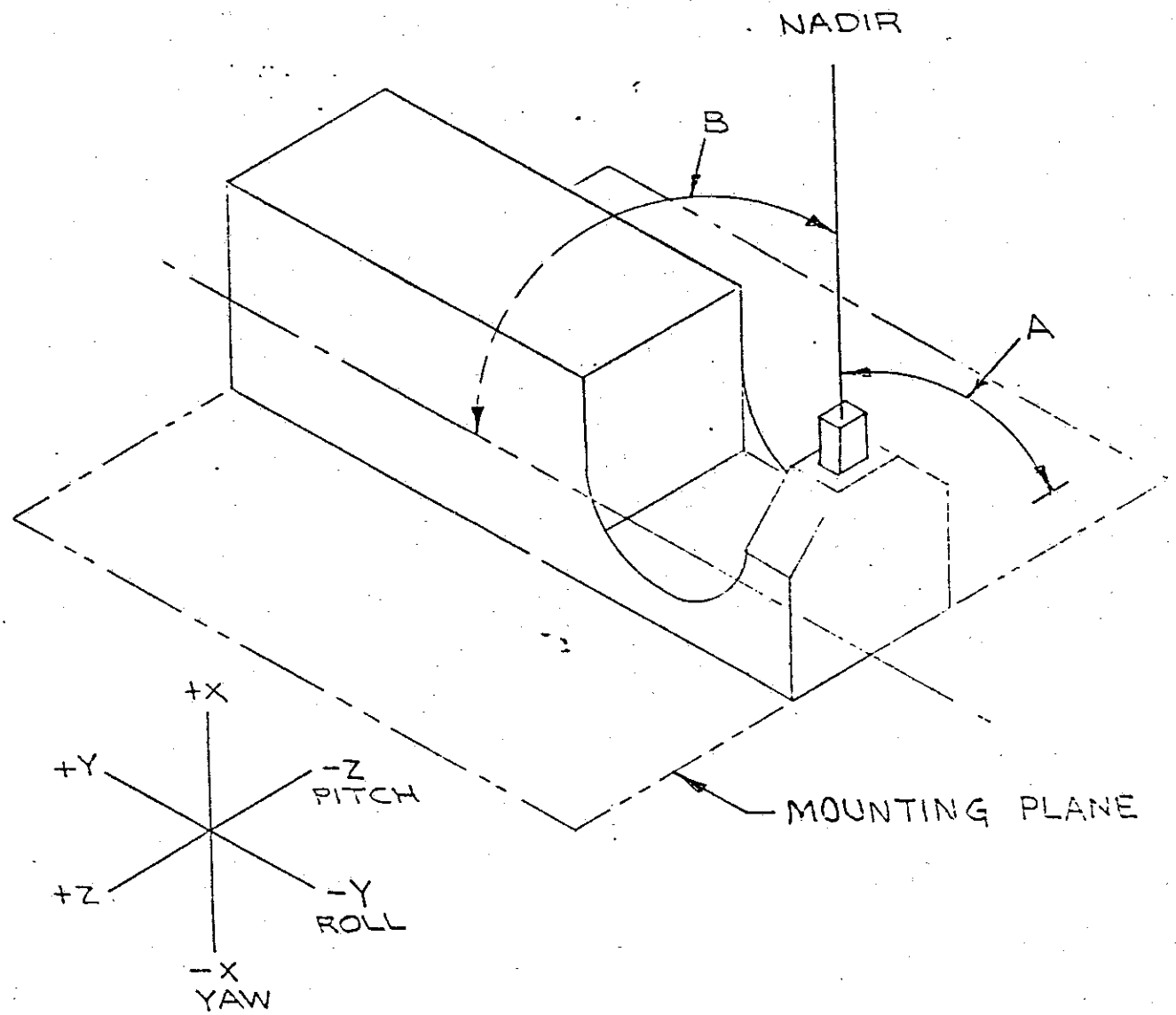


FIGURE 2.3.2

SCAN PLANE TO MOUNTING HOLE PATTERN ANGLE



MOUNTING PLANE TO NADIR ANGLES
(NADIR IS DEFINED TO BE PERINDICULAR TO THE EARTH FACING SIDE OF THE ALIGNMENT CUBE)

FIGURE 2.3.3

3.0 AVHRR/2 CALIBRATION DATA

Final calibration data for the AVHRR/2 PFM is presented in this section. Detailed data and calculations supporting this information is presented in Section 4.0 of this report.

3.1 Visible Channels Calibration (Channels 1 & 2)

Graphs of the output versus percent albedo are presented in Figures 3.1-1 and 3.1-2. A GFE supplied 30 inch diameter Spherical Integrator Source (ref. x-942-75-18) was used as a calibration standard. Detailed calculations and data are covered in Section 4.0 of this report.

3.2 IR Channels Calibration (Channels 3, 4 & 5)

Figures 3.2-1 through 3.2-15 are graphs of the calibration blackbody temperature versus instrument output for Channels 3, 4 & 5 of the AVHRR/2 PFM. This data was taken from Procedure 8125968 and supporting computer print-outs. Calibrations were made at five (5) instrument base-plate temperatures. Section 4.0 contains detailed supporting data.

3.3 Telemetry Calibration

3.3.1 Analog Telemetry

The analog telemetry outputs are presented as nominal calibration equations for each output. Table 3.3.1-1 is a listing of the telemetry and its nominal equation. These equations have been programmed into the BTE computer which results in analog telemetry outputs that monitor instrument performance.

3.3.2 Digital Telemetry

Digital telemetry outputs are indications of command status within the AVHRR/2. These outputs are:

Logic true	-0.1 to +0.4 volts
Logic false	+5.0 $\pm$ 0.7 volts

Table 3.3.2-1 is a listing of the instrument commands and its verification indication.

K+E 5 X 5 TO 1/2 INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0863

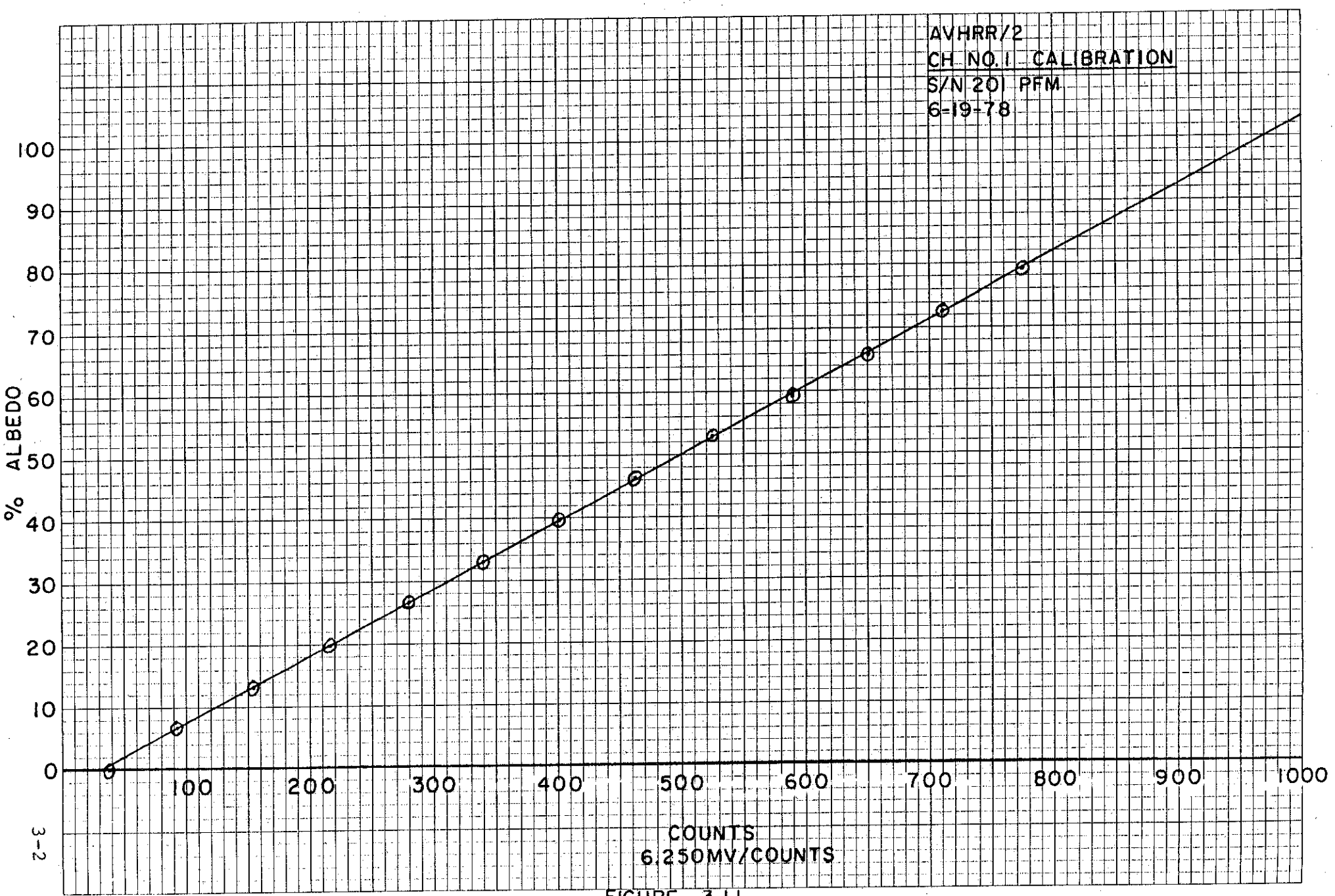


FIGURE 3.1.1

K+E 5 X 5 TO 1/2 INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

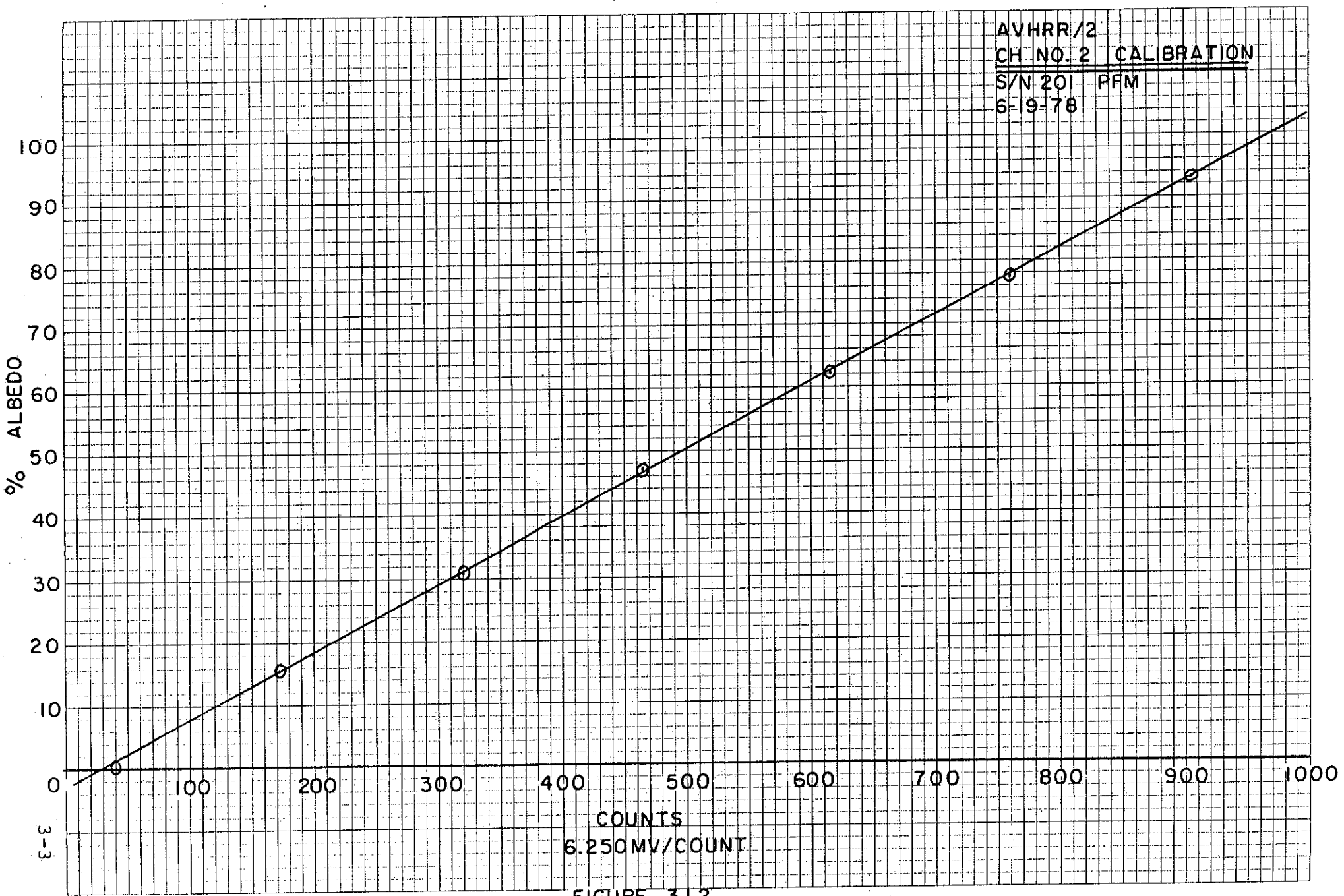
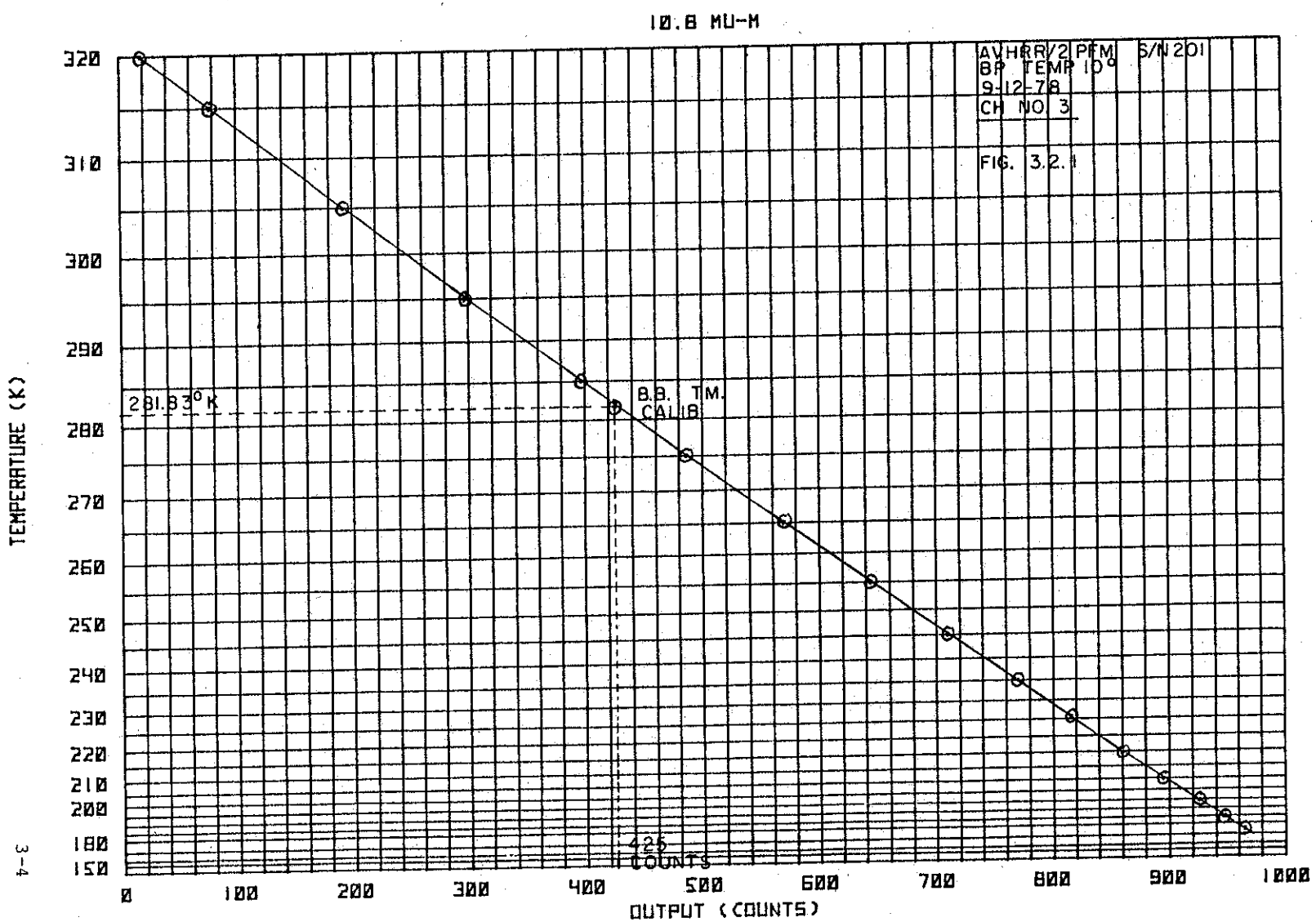
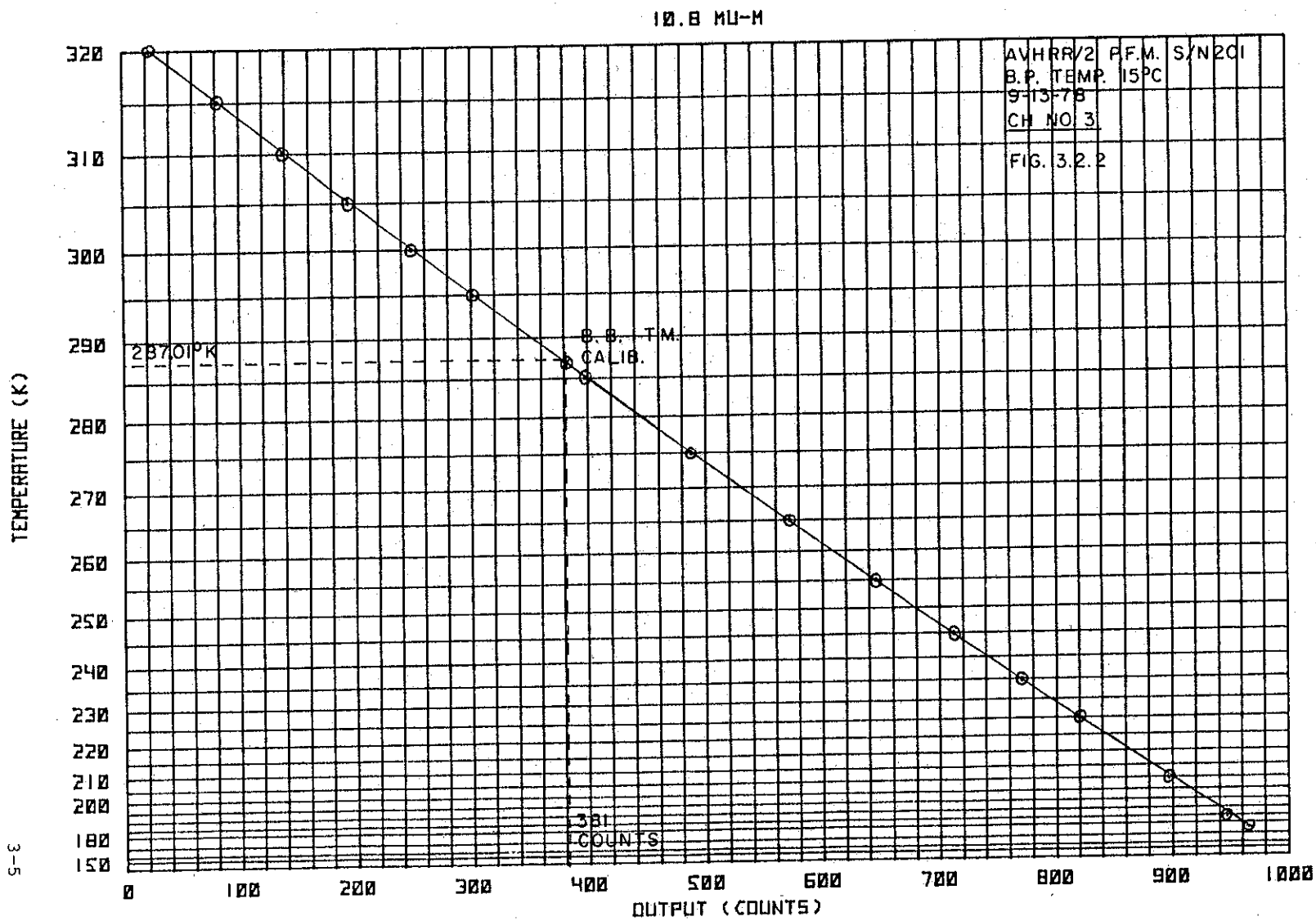
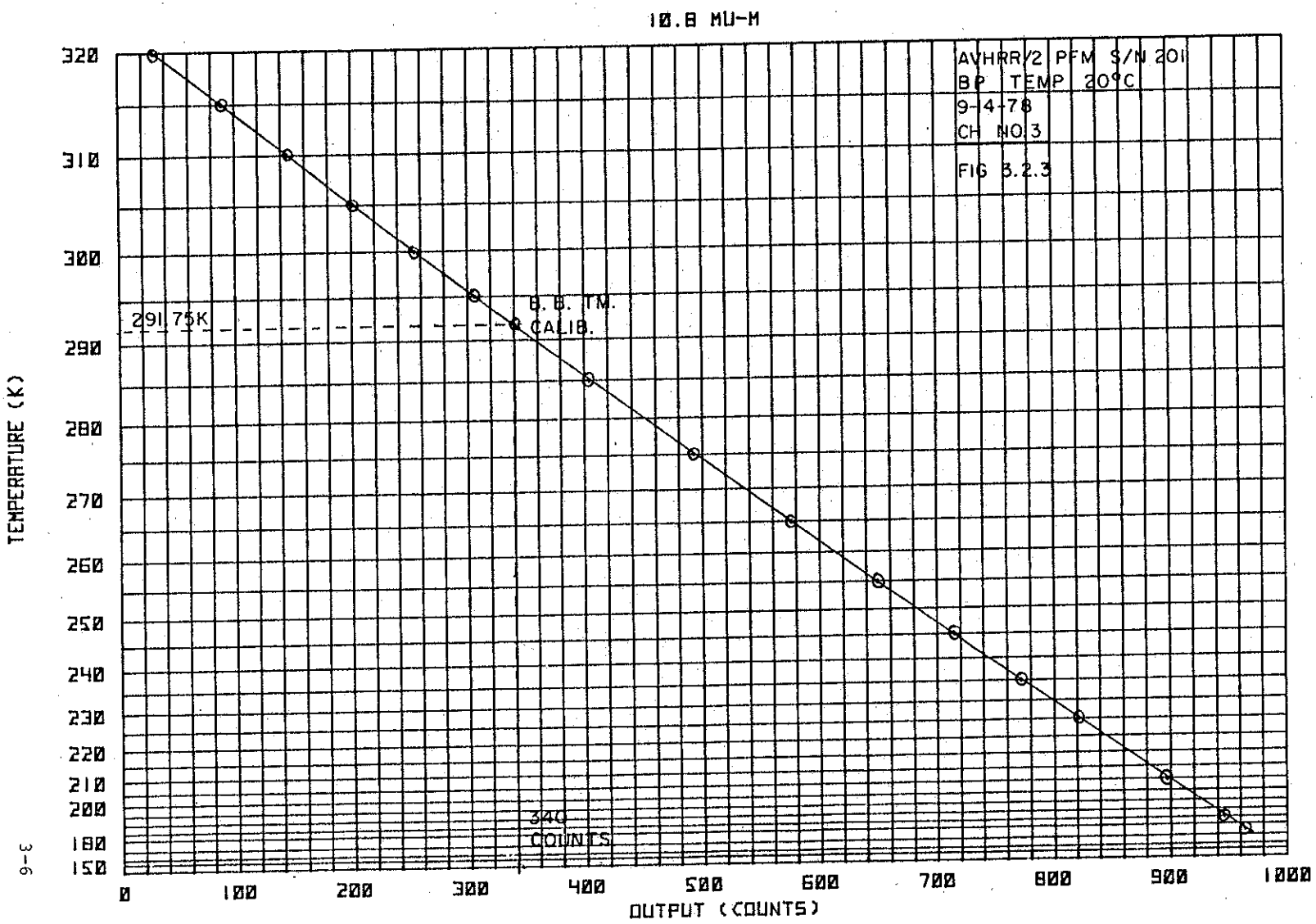
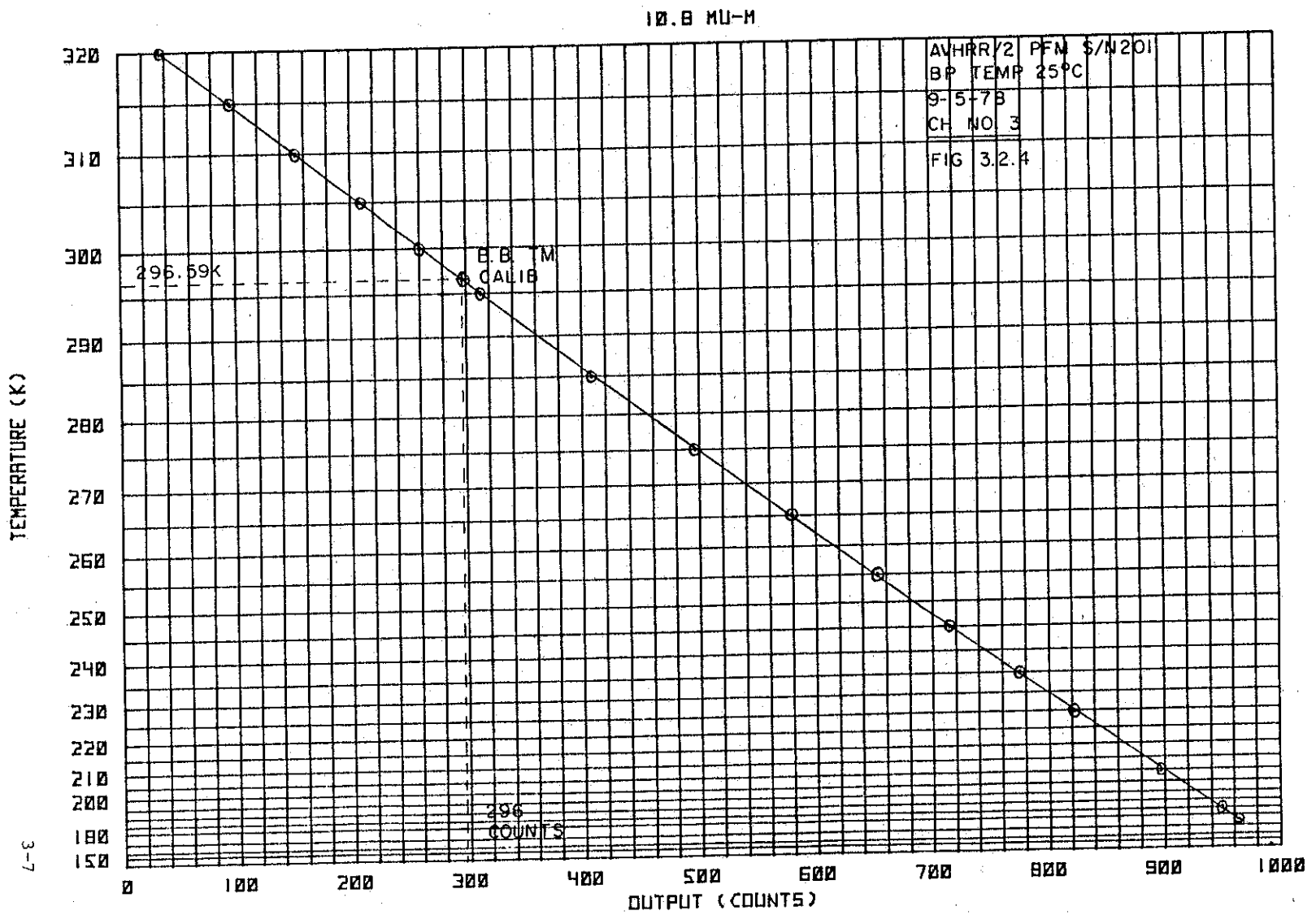


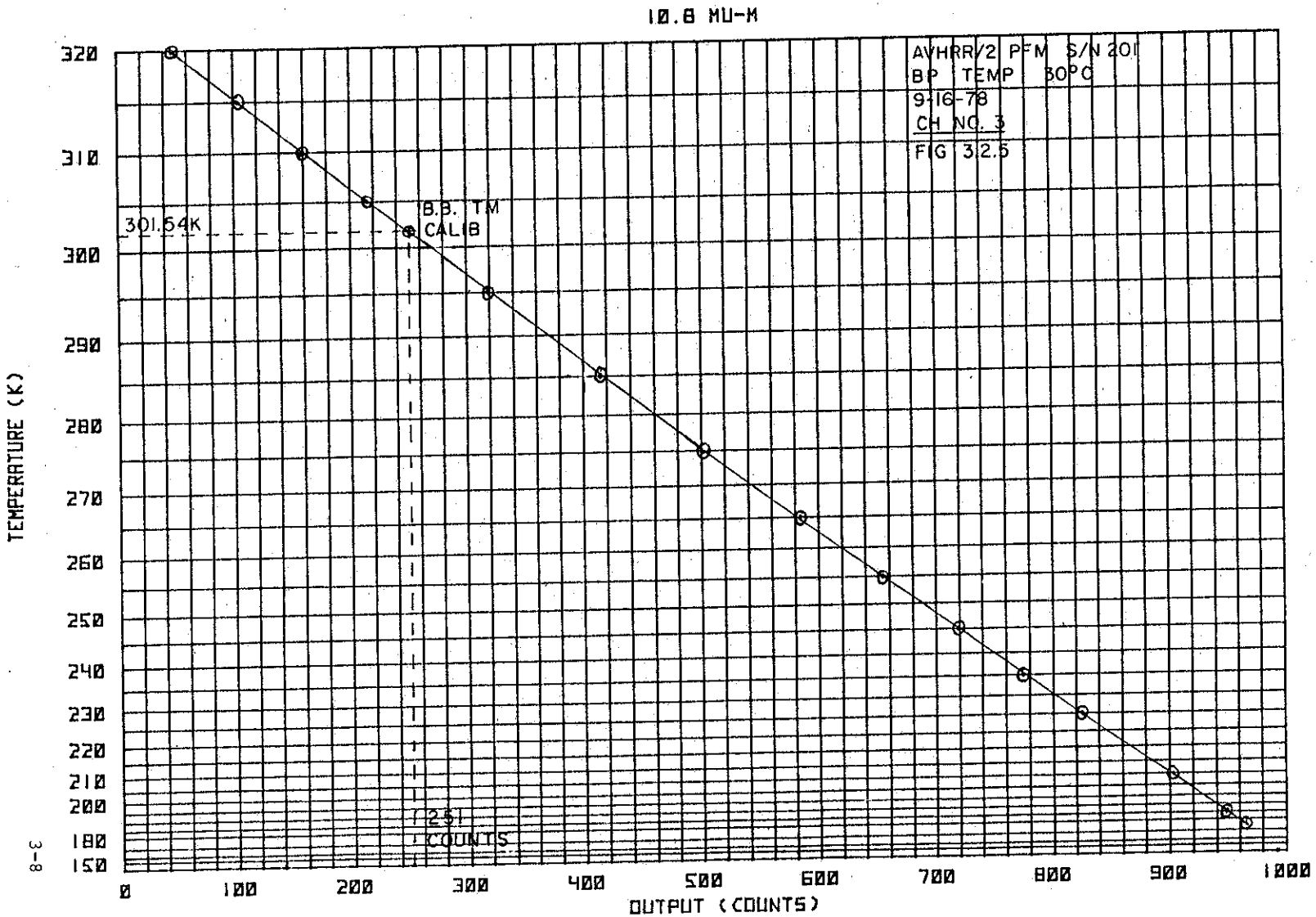
FIGURE 3.1.2

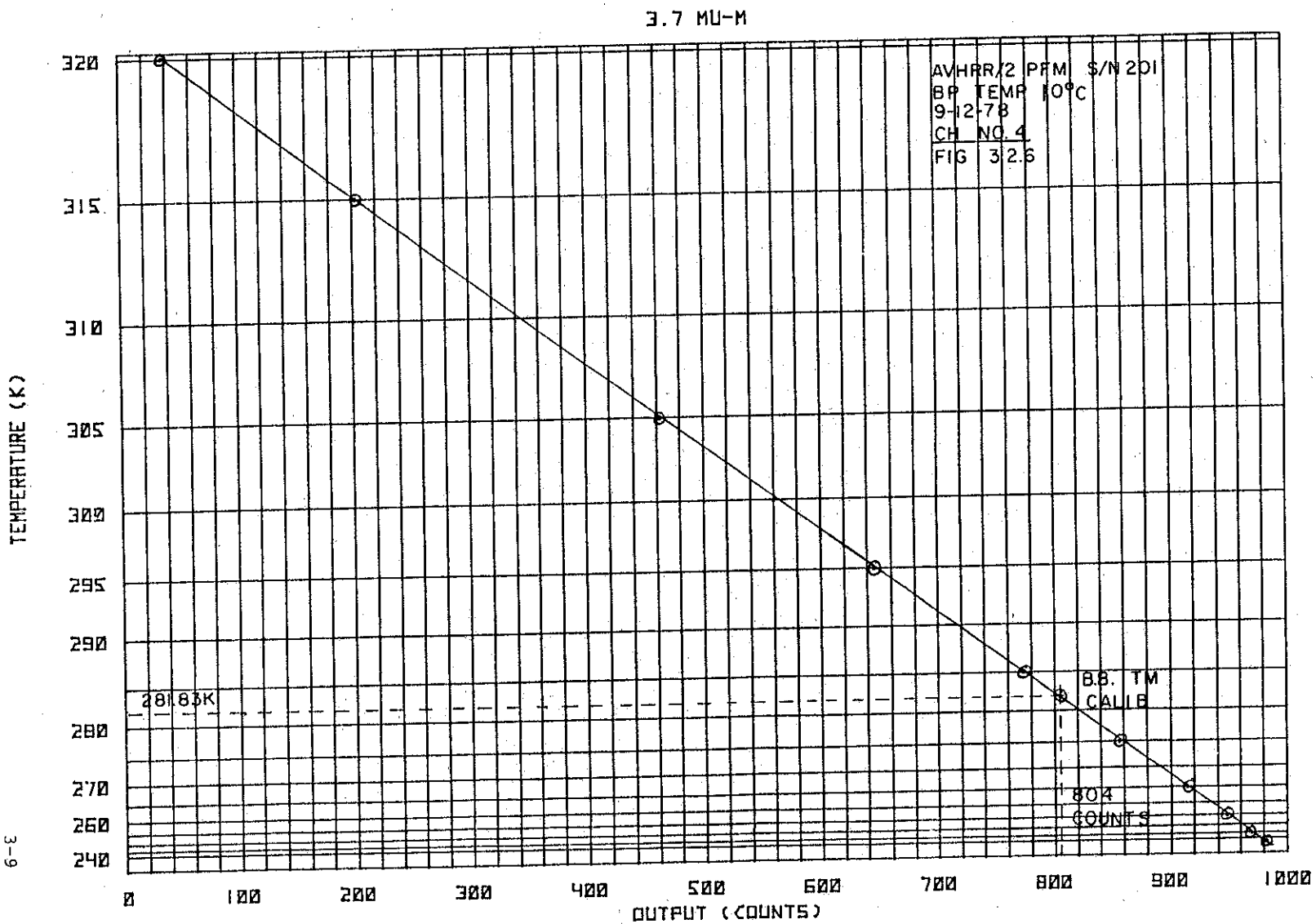

10.8 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 10°
9-12-78
CH NO 3
FIG. 3.2.1
281.83°K
B.B. TM.
CALIB
425
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

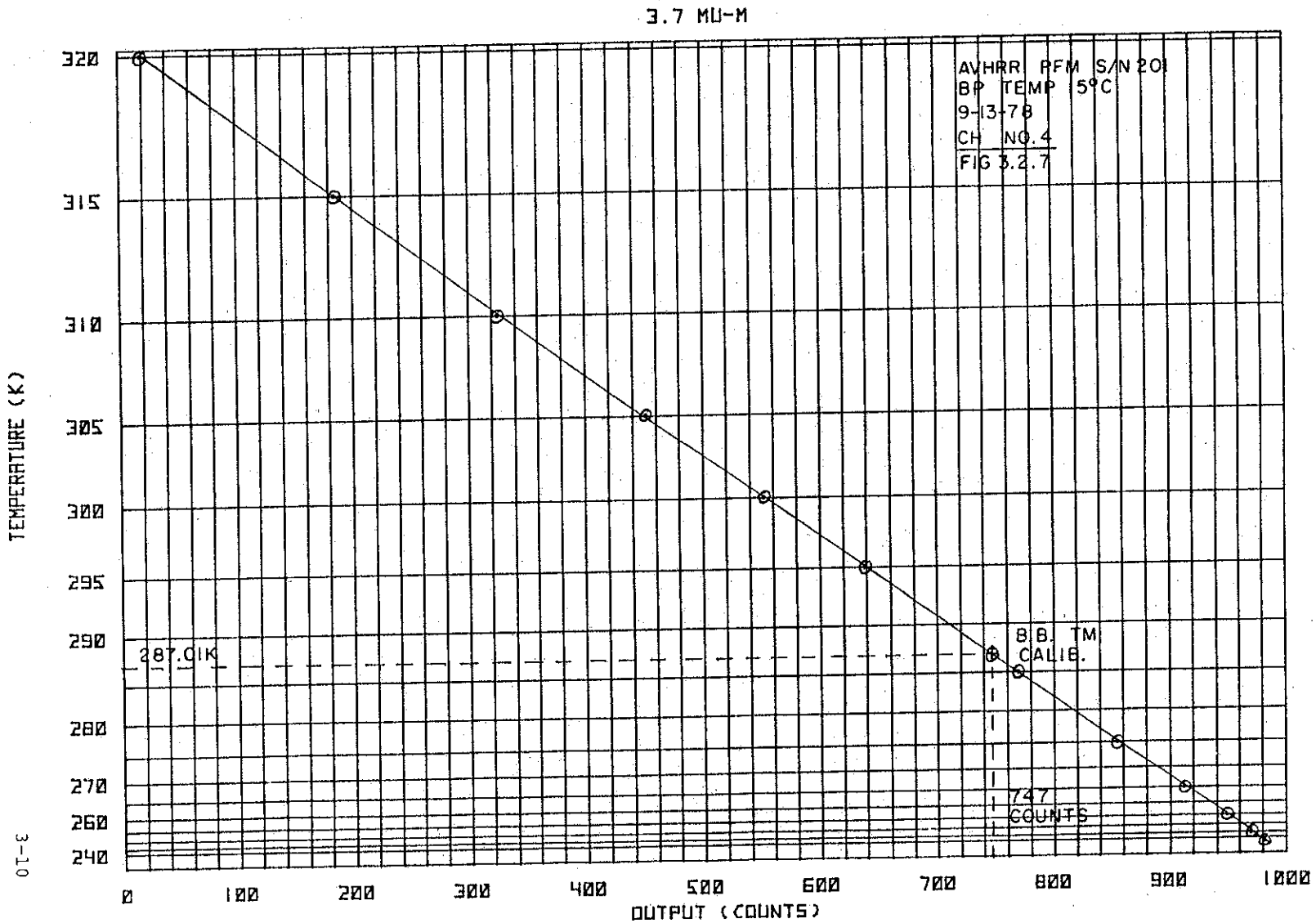

10.8 MU-M
AVHRR/2 P.F.M. S/N201
B.P. TEMP. 15°C
9-13-78
CH NO. 3
FIG. 3.2.2
B.B. TM.
CALIB.
287.01°K
381
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

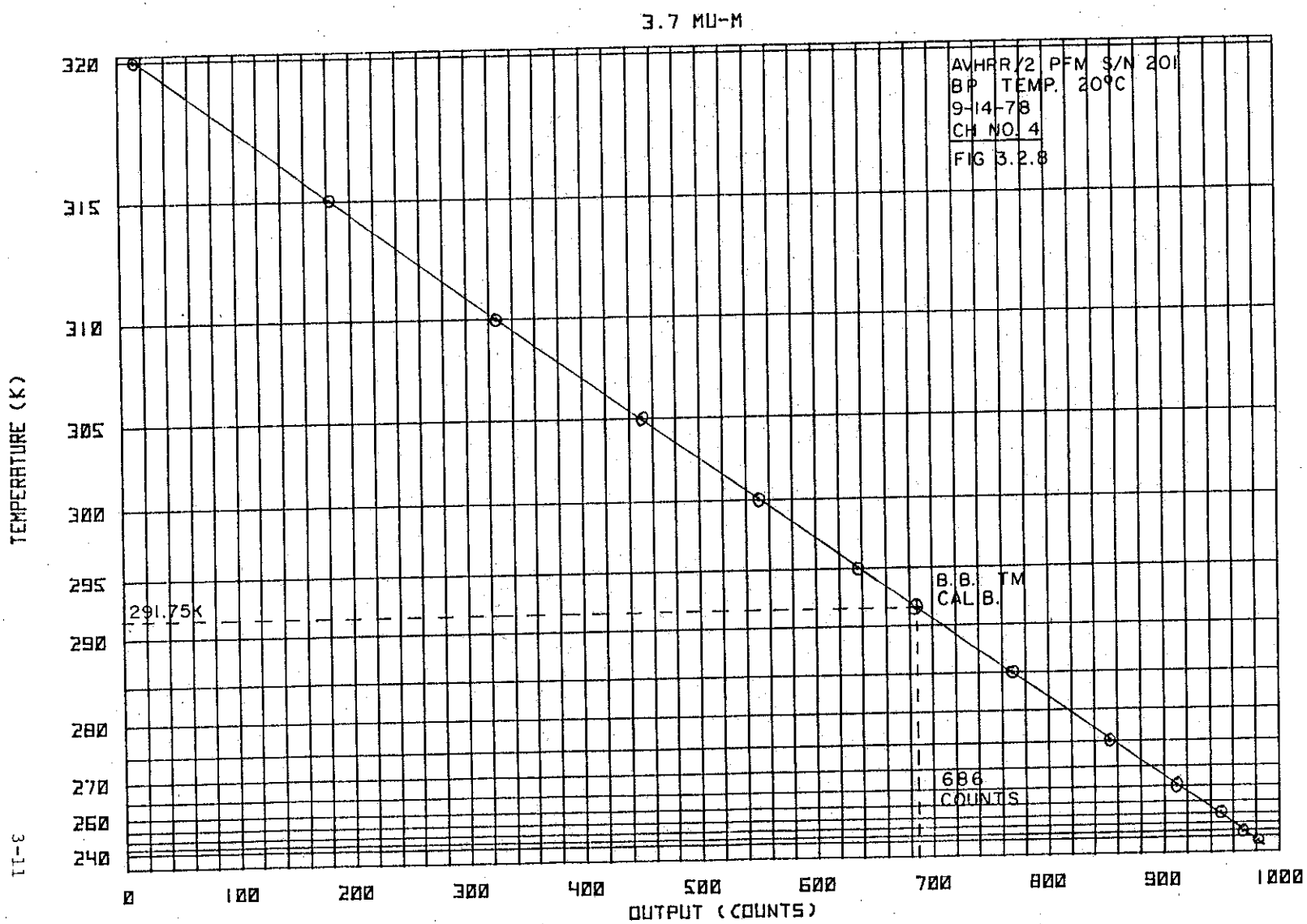

10.8 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 20°C
9-4-78
CH NO.3
FIG 3.2.3
B.B. TM.
CALIB.
291.75K
340
COUNTS
TEMPERATURE (K)
OUTPUT (COUNTS)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000

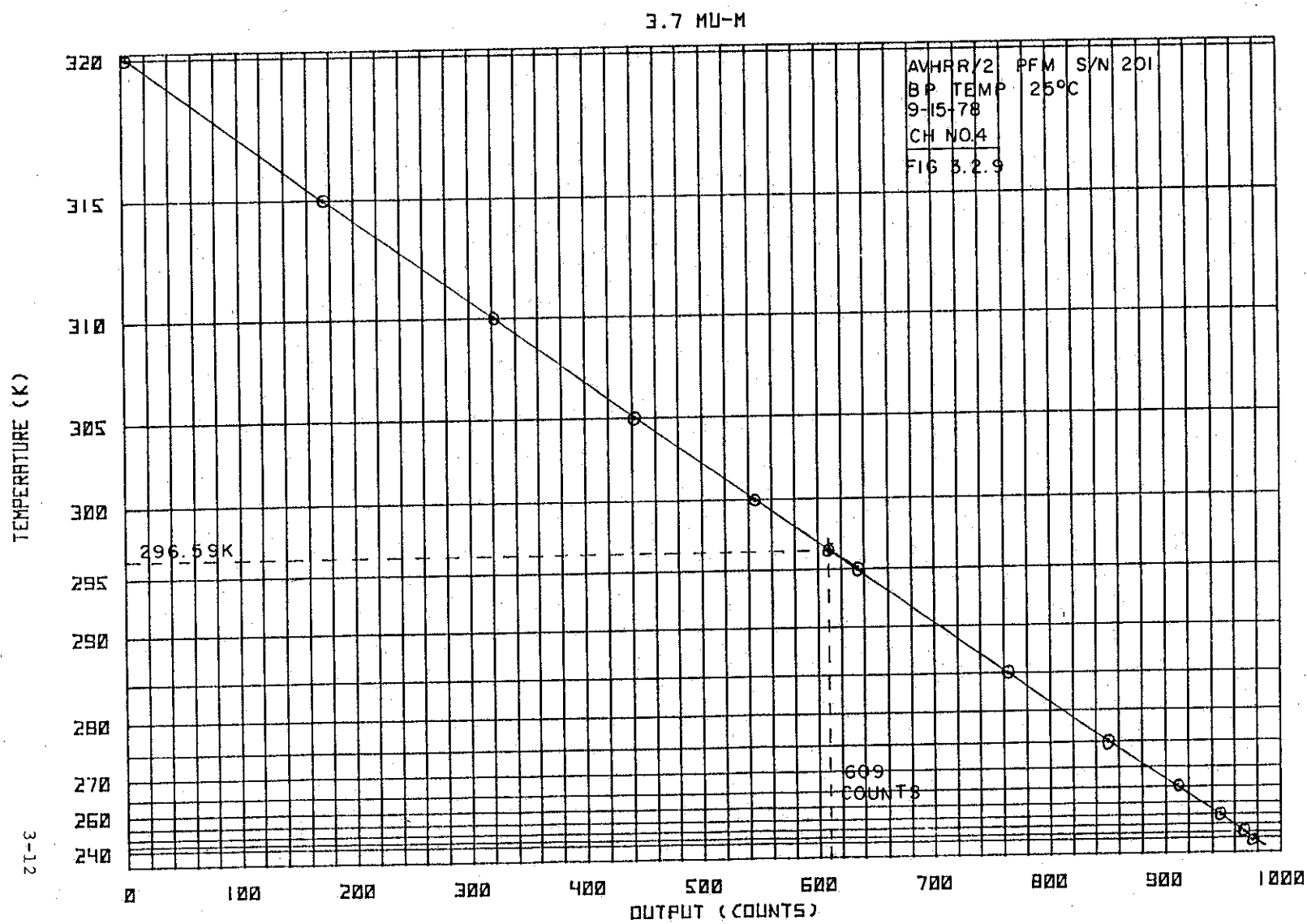

10.8 MU-M
AVHRR/2 PFM S/N201
BP TEMP 25°C
9-5-78
CH NO 3
FIG 3.2.4
B.B. TM
CALIB
296.59K
296
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

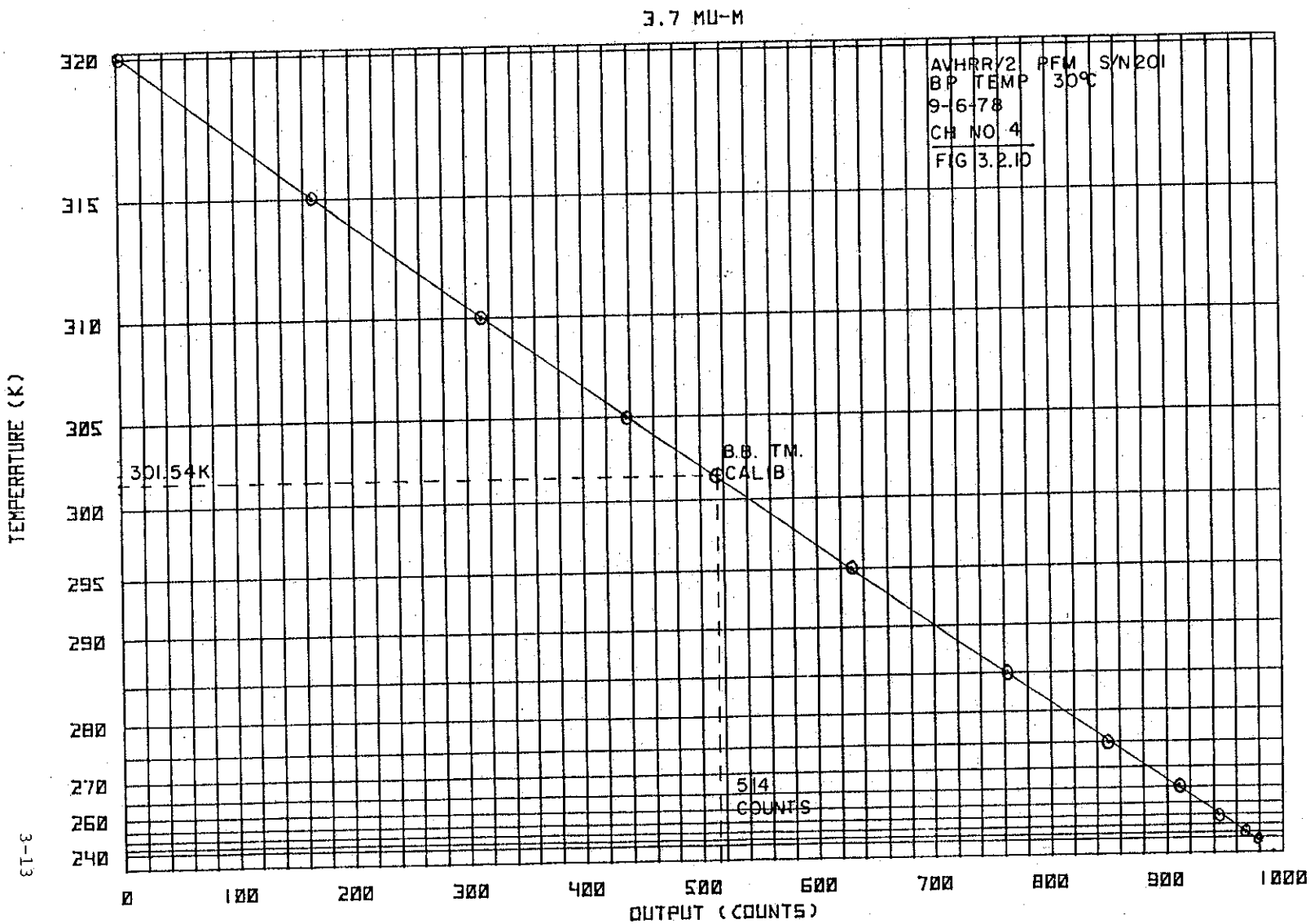

10.8 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 30°C
9-16-78
CH NO. 3
FIG 3.2.5
B.B. TM
CALIB
301.54K
(251)
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

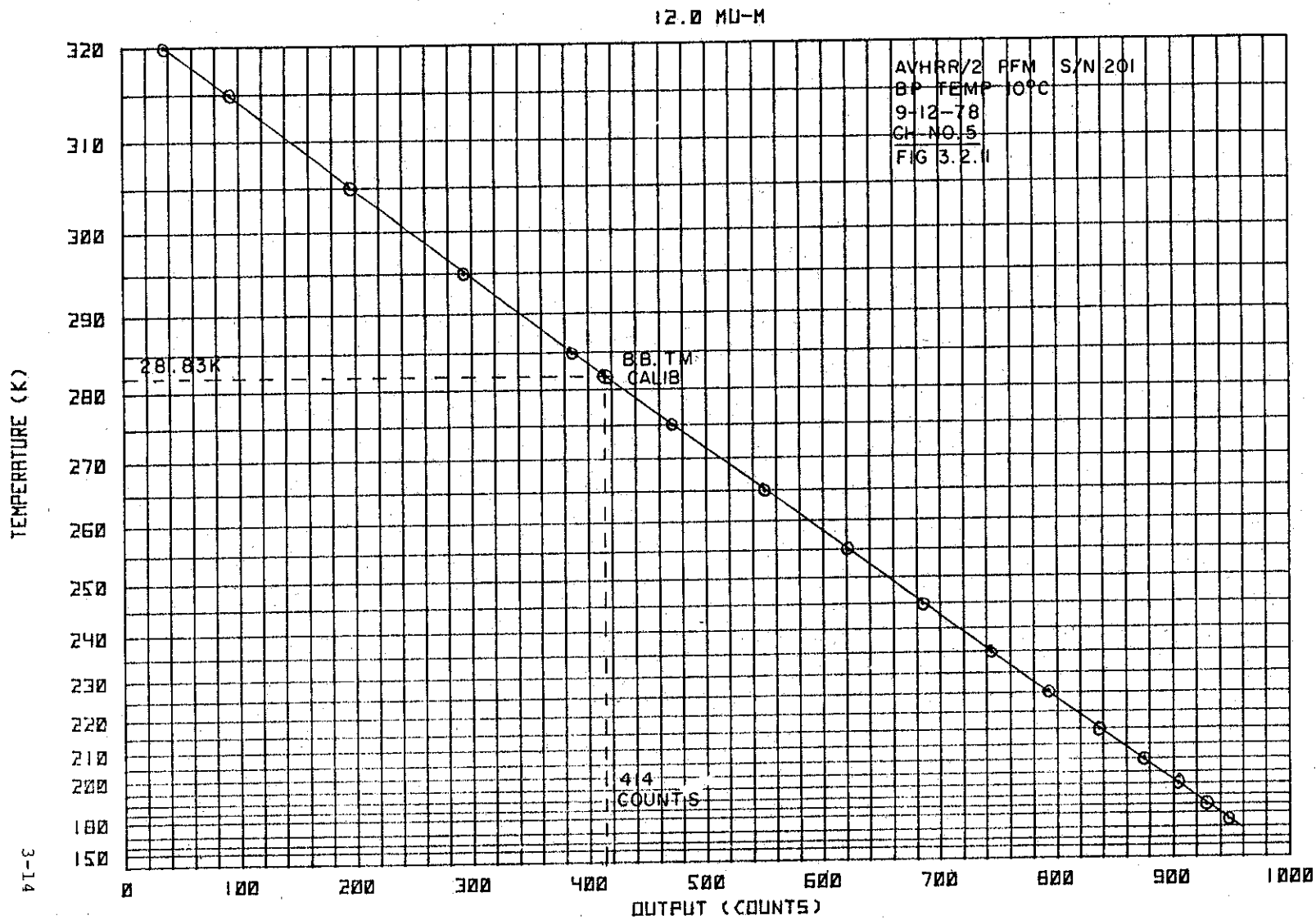

3.7 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 10°C
9-12-78
CH NO. 4
FIG 3.2.6
B.B. TM
CALIB
804
COUNTS
281.83K
TEMPERATURE (K)
320
315
310
305
300
295
290
280
270
260
240
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

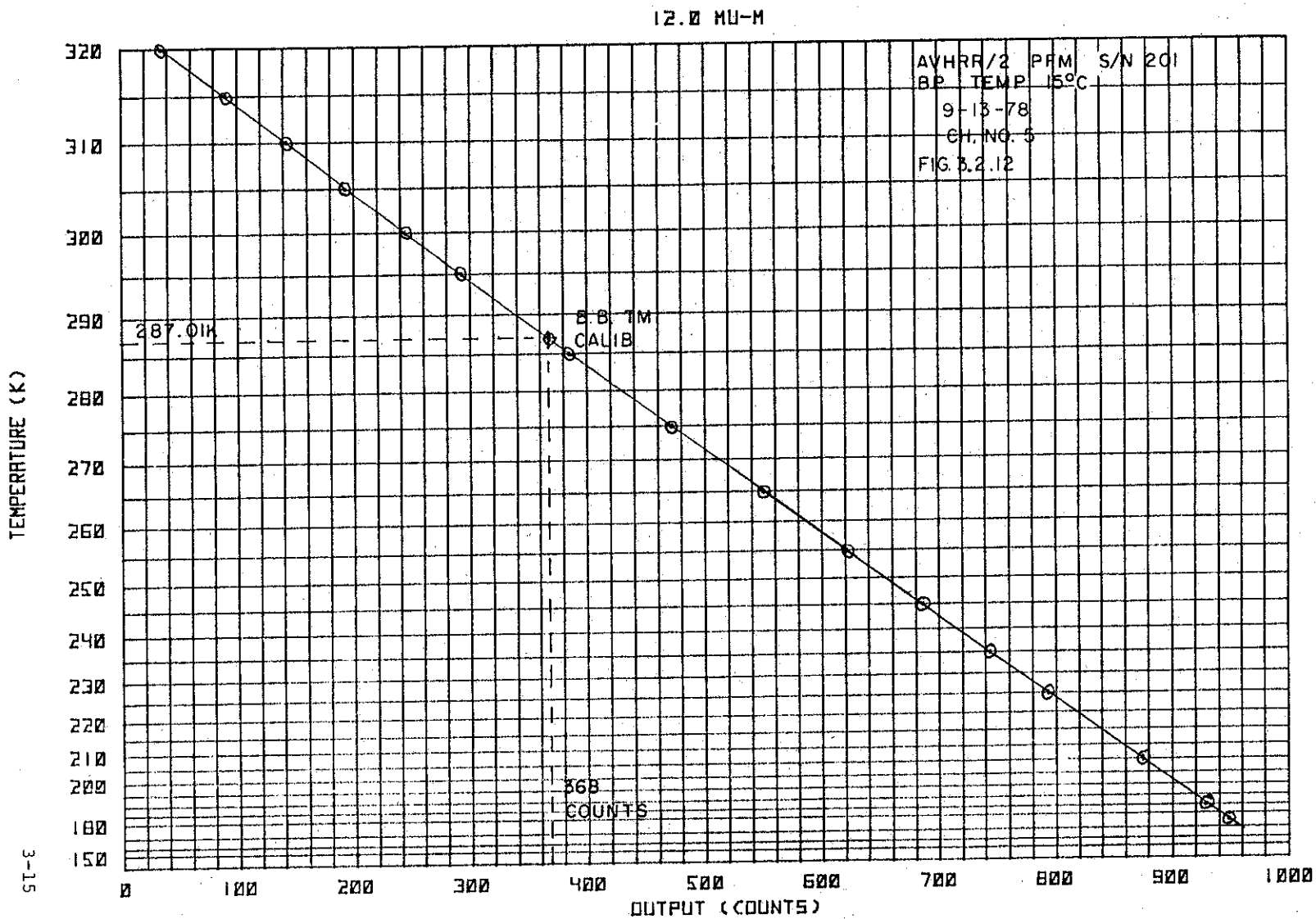

3.7 MU-M
AVHRR PFM S/N 201
BP TEMP 5°C
9-13-78
CH NO.4
FIG 3.2.7
B.B. TM
CALIB.
287.01K
747
COUNTS
TEMPERATURE (K)
320
315
310
305
300
295
290
280
270
260
240
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

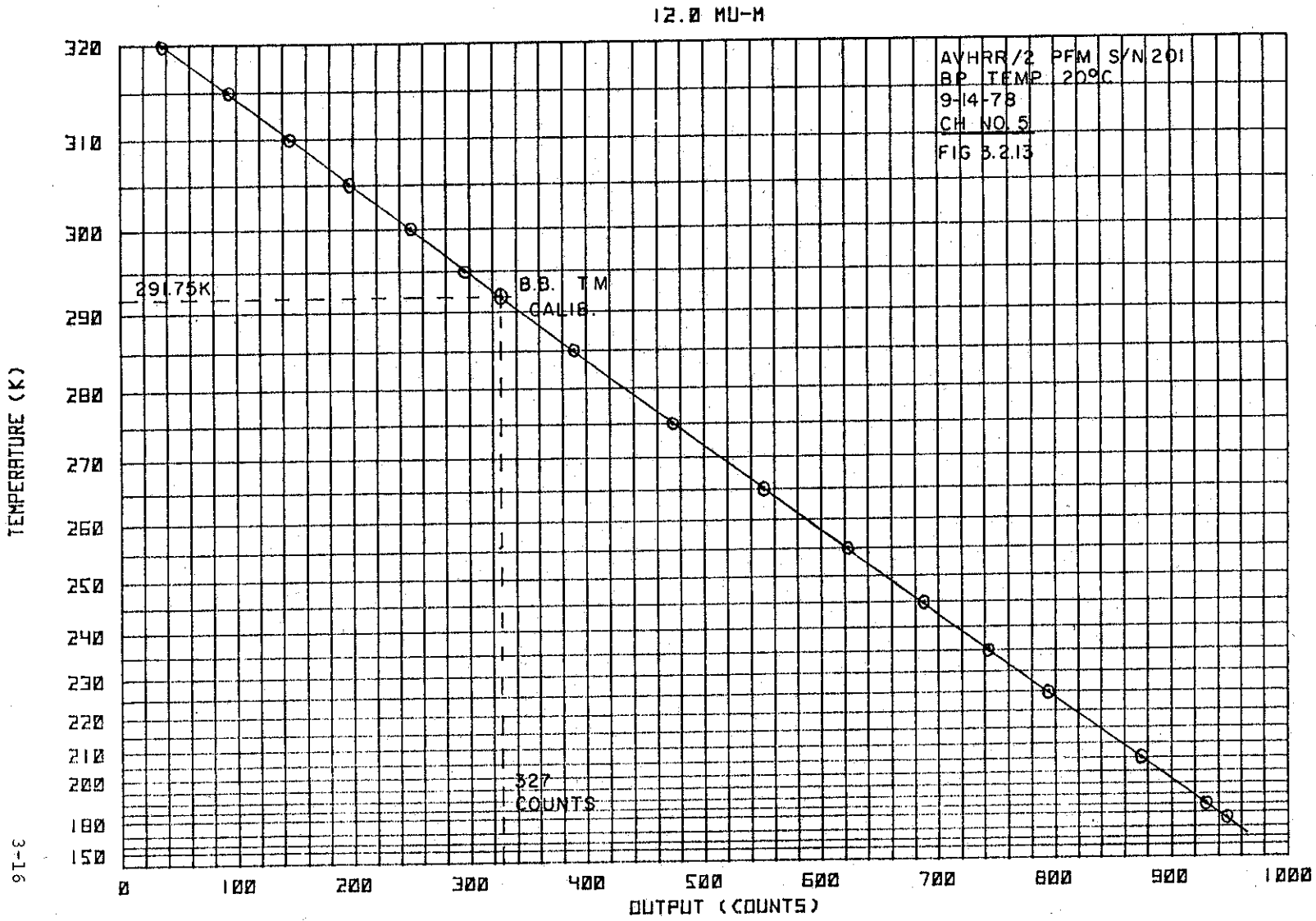

3.7 MU-M
AVHRR/2 PFM S/N 201
BP TEMP. 20°C
9-14-78
CH NO. 4
FIG 3.2.8
B.B. TM
CAL B.
291.75K
686
COUNTS
TEMPERATURE (K)
320
315
310
305
300
295
290
280
270
260
240
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

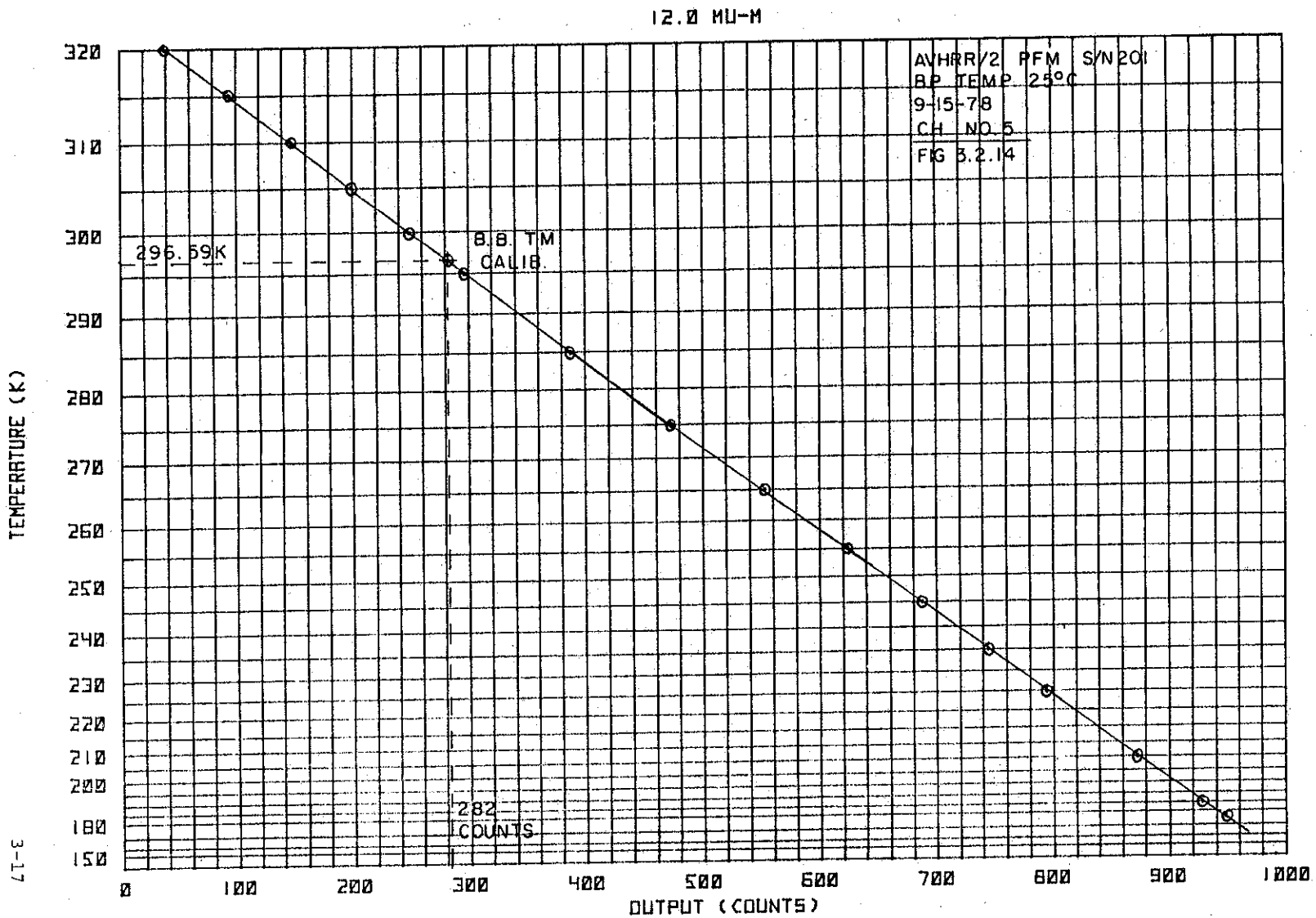

3.7 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 25°C
9-15-78
CH NO.4
FIG 3.2.9
296.59K
609
COUNTS
TEMPERATURE (K)
320
315
310
305
300
295
290
280
270
260
240
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

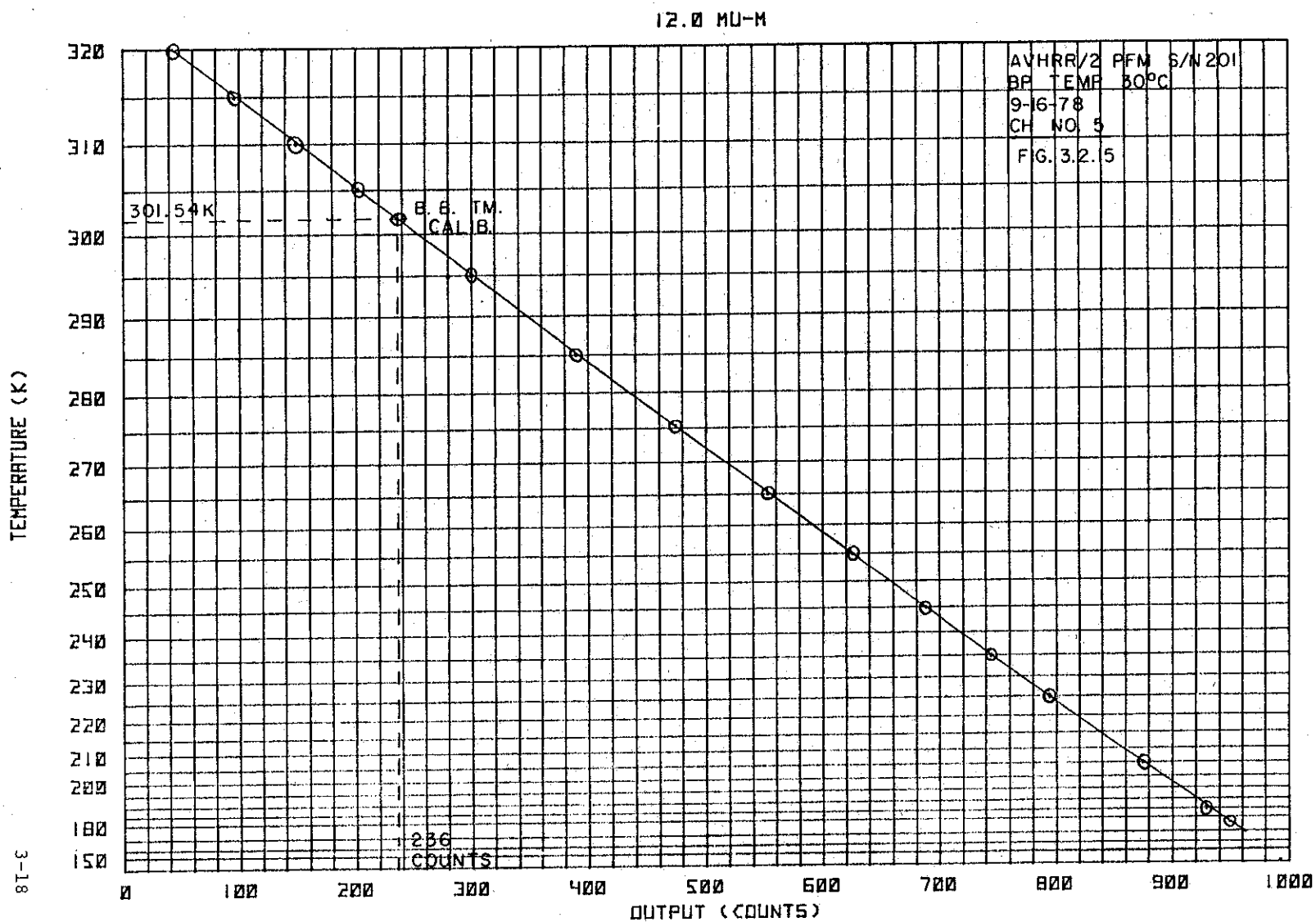

3.7 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 30°C
9-6-78
CH NO 4
FIG 3.2.10
B.B. TM.
CAL. B
301.54K
514
COUNTS
TEMPERATURE (K)
320
315
310
305
300
295
290
280
270
260
240
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)


12.0 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 10°C
9-12-78
CH NO.5
FIG 3.2.11
B.B. TM
CALIB
28.83K
414
COUNTS
TEMPERATURE (K)
OUTPUT (COUNTS)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000


12.0 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 15°C
9-13-78
CH. NO. 5
FIG. 3.2.12
B.B. TM
CALIB
287.01K
368
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)


12.0 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 20°C
9-14-78
CH NO. 5
FIG 3.2.13
291.75K
B.B. TM
CALIB.
327
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)


12.0 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 25°C
9-15-78
CH NO 5
FIG 3.2.14
296.59K
8.8 TM
CALIB.
282
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)


12.0 MU-M
AVHRR/2 PFM S/N 201
BP TEMP 30°C
9-16-78
CH NO. 5
FIG. 3.2.5
301.54K
B. B. TM.
CAL B.
236
COUNTS
TEMPERATURE (K)
320
310
300
290
280
270
260
250
240
230
220
210
200
180
150
0
100
200
300
400
500
600
700
800
900
1000
OUTPUT (COUNTS)

AVHRR/2 PFM

CALIBRATION EQUATIONS

RADIATOR TEMP	^{o}K	=	$32.584\ V + 141.692 + .452V^2$
PATCH POWER	MW	=	$2V^2$
PATCH TEMP LOW RANGE	^{o}K	=	$4.997\ V + 90.005 + .0297\ V^2$
PATCH TEMP EX RANGE	^{o}K	=	$34.826\ V + 90.769 + 2.074\ V^2$
BB#1 TM	^{o}C	=	$.0349\ V^2 + 8.204\ V + 3.437$
BB#2 TM	^{o}C	=	$.0349\ V^2 + 8.204\ V + 3.437$
BB#3 TM	^{o}C	=	$.0349\ V^2 + 8.204\ V + 3.437$
BB#4 TM	^{o}C	=	$.0349\ V^2 + 8.204\ V + 3.437$
MOTOR CURRENT	MA	=	60V
ELECTRONICS CURRENT	MA	=	196.5 V
EARTH SHIELD POSITION		=	<2V - CL .2-4 - MID >4V - OPEN
ELECTRONICS TEMP	^{o}C	=	$-5.82V + 39.9$
BASE PLATE TEMP	^{o}C	=	$-7.75V + 34.8$
A TO D TEMP	^{o}C	=	$-8.33V + 86.16$
MOTOR HOUSING TEMP	^{o}C	=	$-7.75V + 34.8$
COOLER HOUSING TEMP	^{o}C	=	$-7.75V + 34.8$
DETECTOR BIAS VOLTS		=	$4.33V - 21.33$
BB IR CH 3	^{o}C	=	$49.37 - 14.839\ V + .8329\ V^2 - .4582\ V^3 + .03498\ V^4$
BB IR CH 4	^{o}C	=	$19.85 + 28.696\ V - 15.116\ V^2 - 2.939\ V^3 - .23074\ V^4$
BB IR CH 5		=	$44.3544 - 2.397\ V - 9.581\ V^2 - 2.966\ V^3 - .37407\ V^4$
OFFSET VOLTAGE	TM	=	1.33 V

TABLE 3.3.1-1

TABLE 3.3.2-1

COMMAND VERIFICATION TELEMETRY

Telemetry Channel	Telemetry Point	Status Indicated	
		Logic True	Logic False
		(0 volts)	(+5 volts)
1	Scan Motor/Telemetry	ON	OFF
2	Electronics/Telemetry	ON	OFF
3	Channel 1	Enable	Disable
4	Channel 2	Enable	Disable
5	Channel 3	Enable	Disable
6	Channel 4	Enable	Disable
7	Channel 5	Enable	Disable
8	Voltage Calibrate	ON	OFF
9	Patch Control Mode	High	Low
10	Cooler Heat	ON	OFF
11	Scan Motor Mode	High	Low
12	Housekeeping Telemetry	Locked ON	Not Locked ON
13	Earth Shield	Deploy	Disable
14	Patch Control	ON	OFF

3.4 Spectral Characteristics

The spectral response of the AVHRR/2 Protoflight Model was measured in accordance with Test Procedure 8125979. The measured response of the five channels is presented on the following five graphs. Pertinent features such as location of the 50 percent response wavelengths, cutoff slopes, etc. are given in Tables 5, 7. Detailed test data is presented in Section 4.0 of this report.

3.5 IFOV Characteristics (8125965)

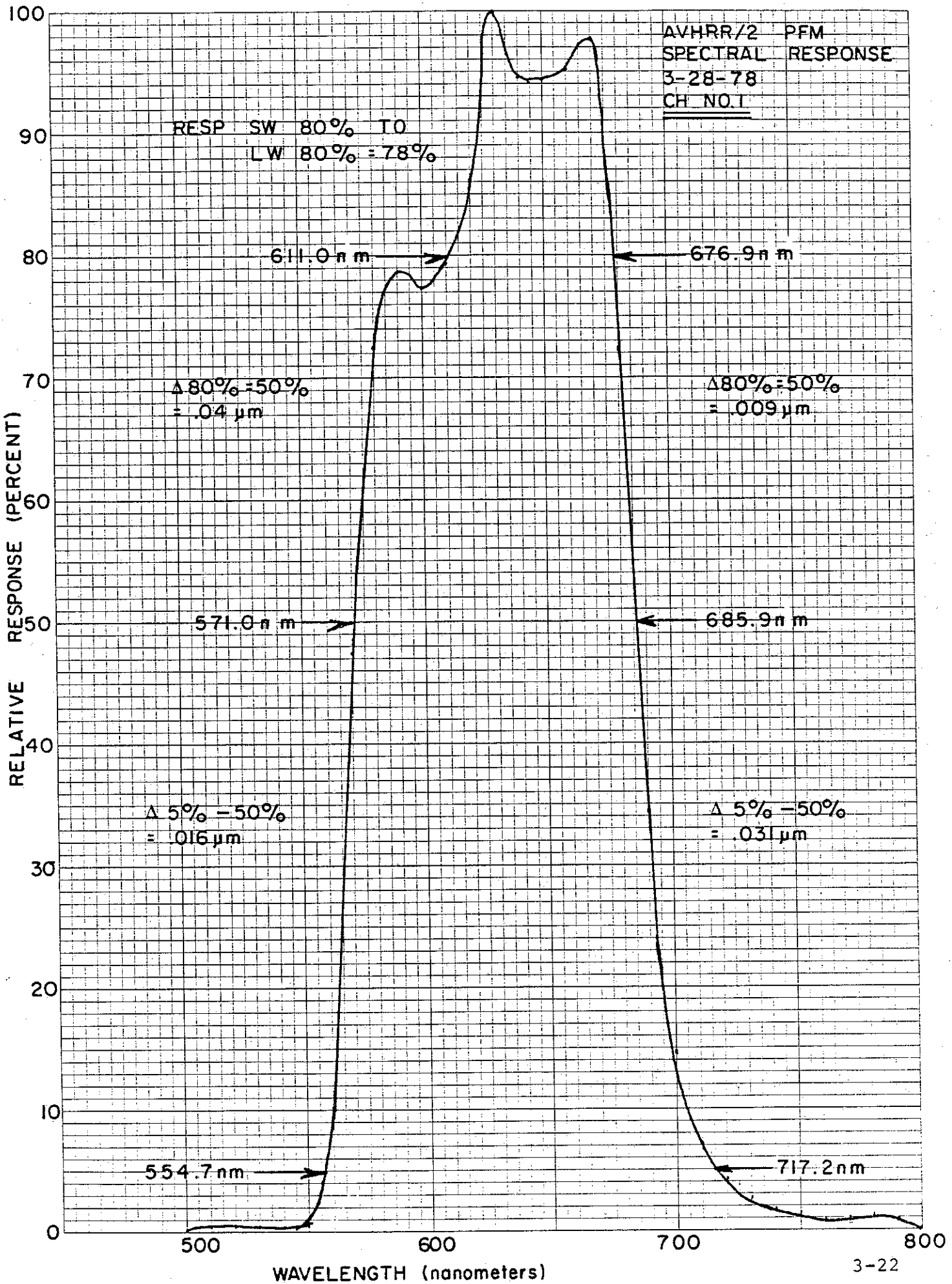
The plots of the IFOV of the five channels in the scan and the cross scan direction are presented in the following 10 graphs. These curves were run at the final bench test level. Detailed data is presented in Section 4.0 of this report.

3.6 Channel Registration

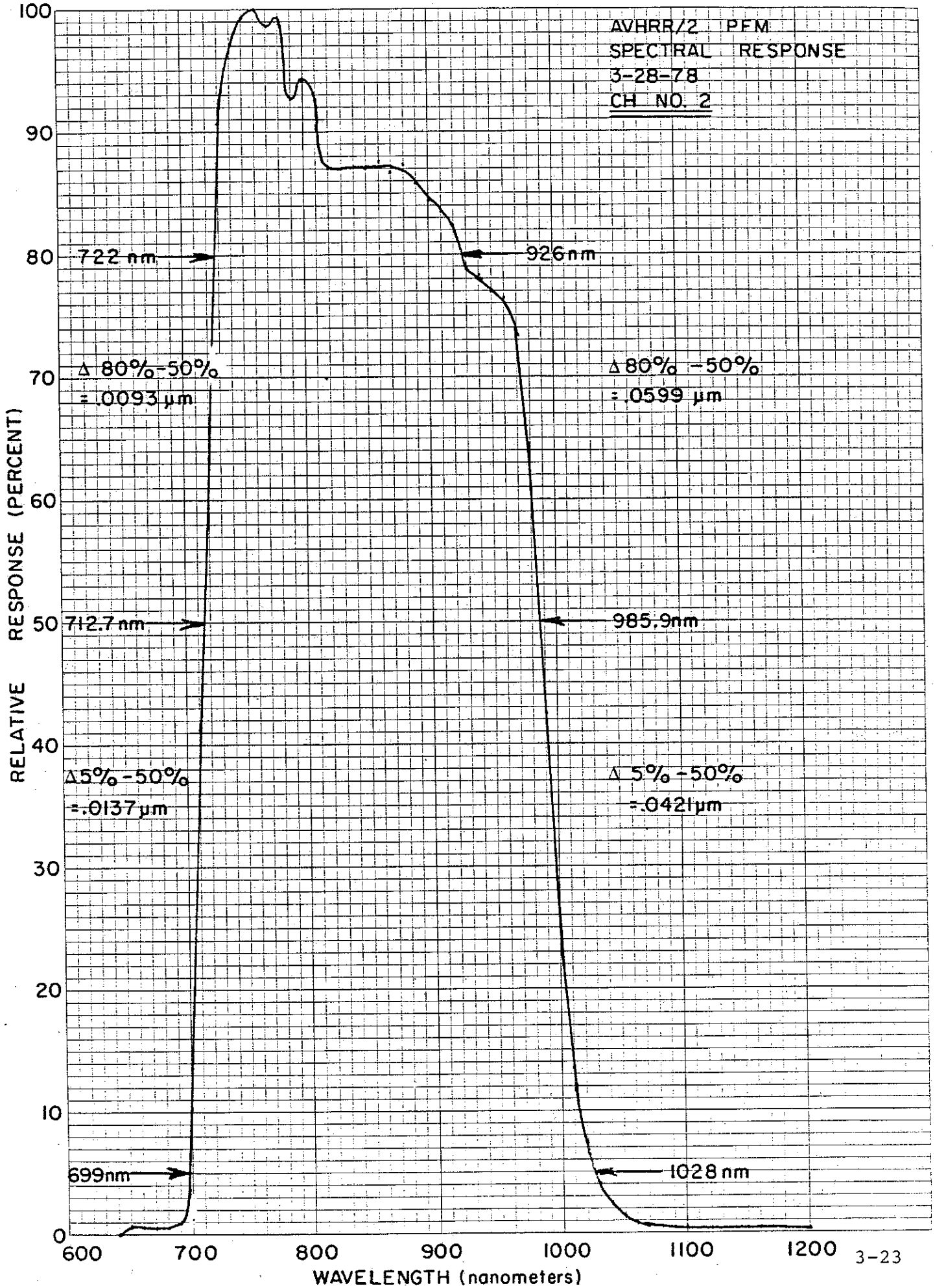
The following graph is a plot at the four channels indicating the relative positions of the center of each channel. This measurement is made at the local plane of the test collimator where the scale is in .1 mils increments and 4.92 mils equal .1m rad. Detailed test data is presented in Section 4.0 of this report.

3.7 MTF

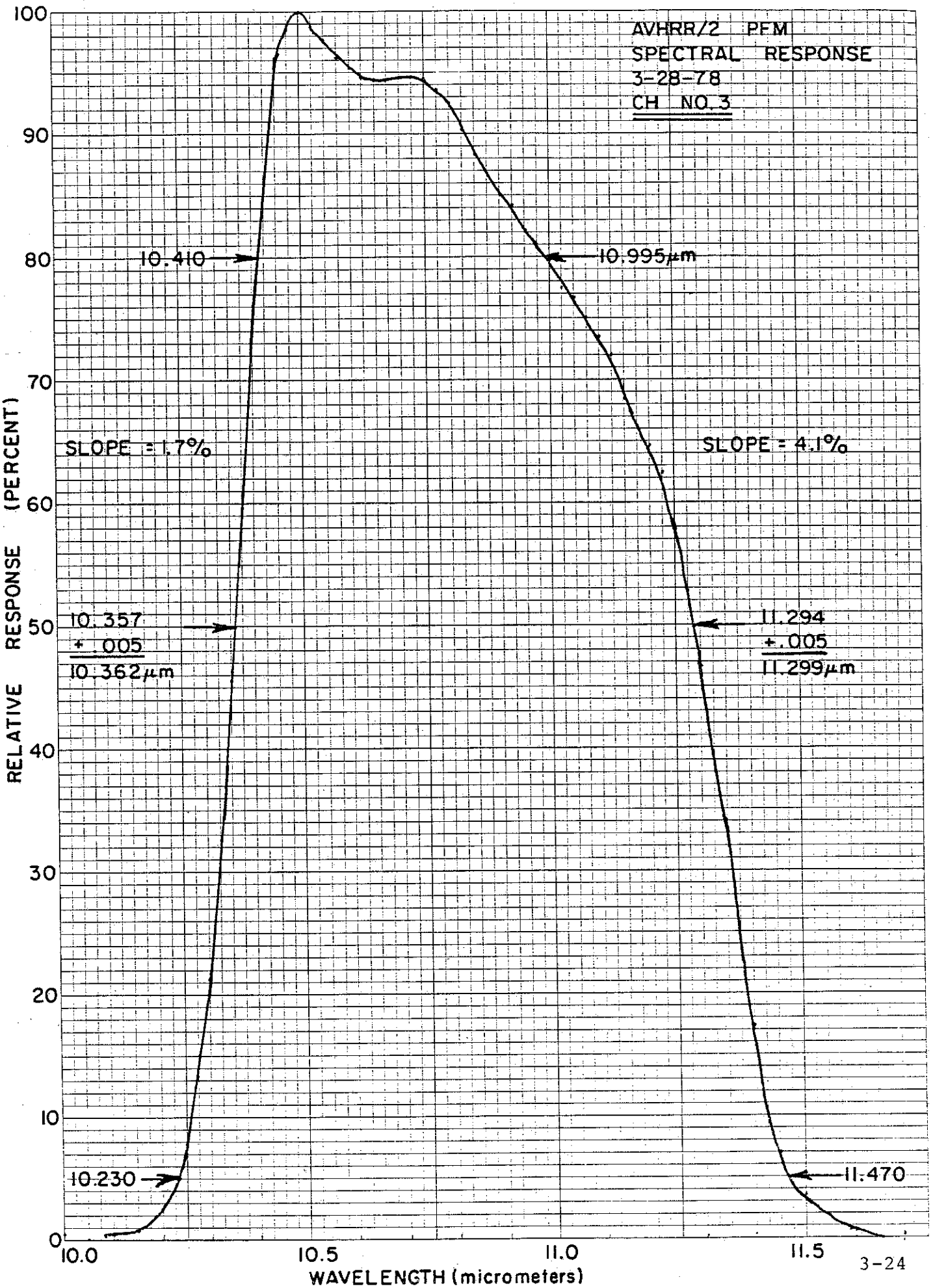
Figure 3.7.1 is a tabulation of the measured MTF data of the PFM. Data is plotted at spatial frequency versus relative response and is measured in the scan and cross scan directions of the system. Supporting data is presented in Section 4.2 of this report.



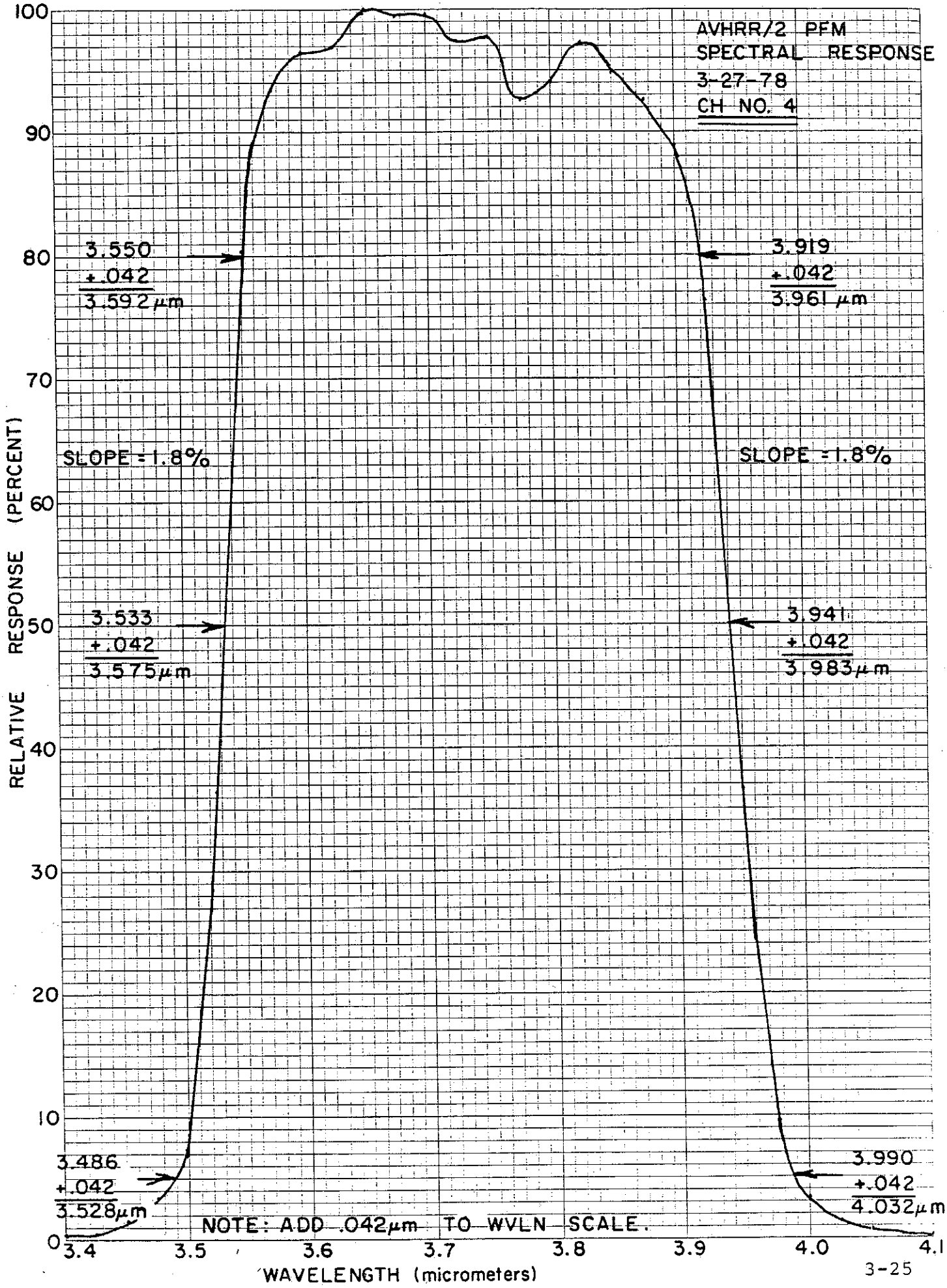
46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



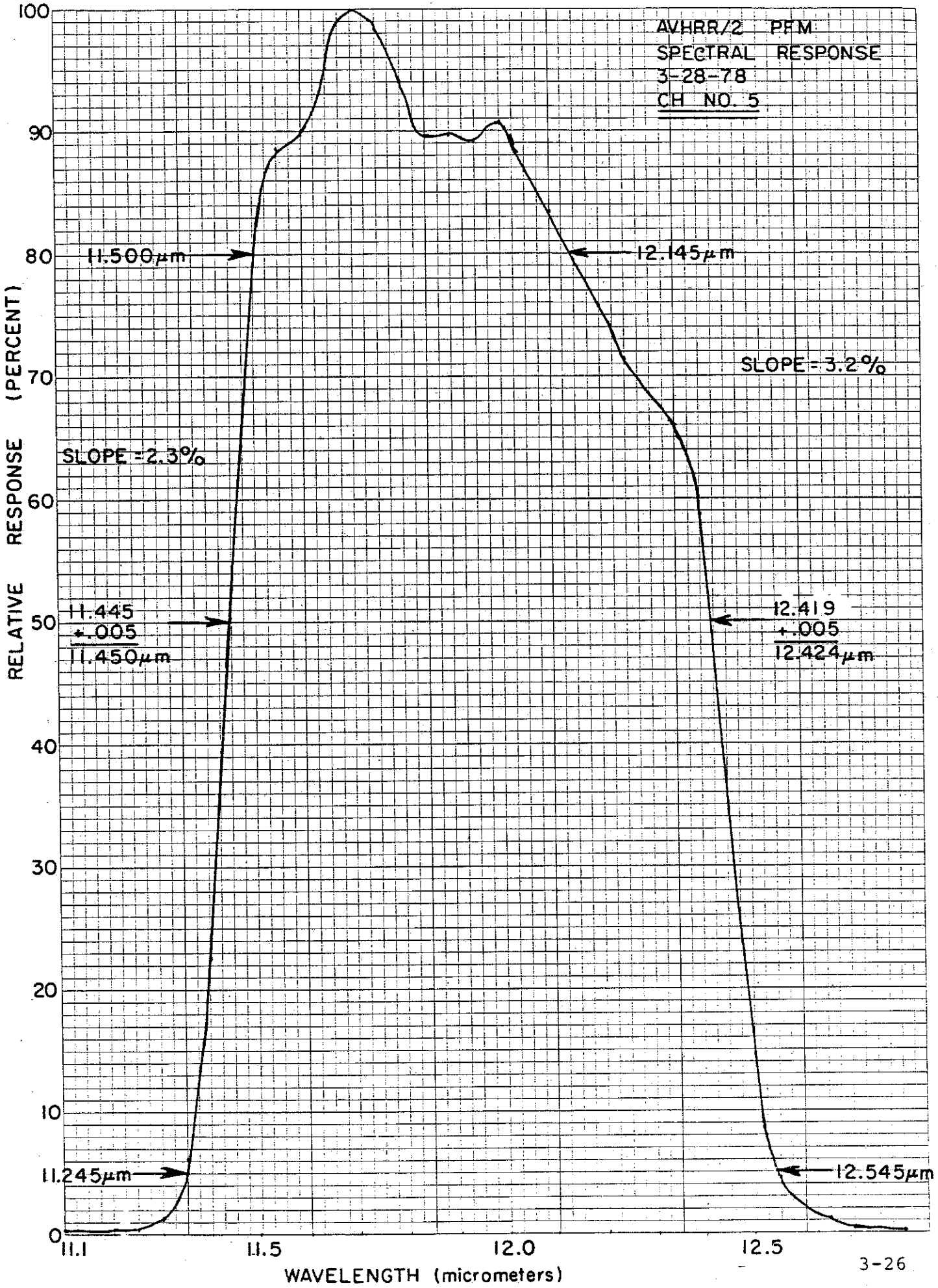
46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

AVHRR/201/PFM

	CHANNEL 1		CHANNEL 2	
	SPEC.	MEASURED	SPEC.	MEASURED
SHORTWAVE 80% WV'LN.	WITHIN 0.04μm OF 50% WV'LN.	.04μm	WITHIN 0.02μm OF 50% WV'LN.	.0093μm
SHORTWAVE 50% WV'LN.	0.58±0.04μm	.571μm	0.725±.025μm	712.7μm
SHORTWAVE 5% WV'LN.	WITHIN 0.14μm OF 50% WV'LN.	.016μm	WITHIN 0.04μm OF 50% WV'LN.	.0137μm
LONGWAVE 80% WV'LN.	WITHIN 0.02μm OF 50% WV'LN.	.009μm	WITHIN 0.2μm OF 50% WV'LN.	.0599μm
LONGWAVE 50% WV'LN.	0.68±0.04μm	.6859μm	1.00±0.05μm	.9859μm
LONGWAVE 5% WV'LN.	WITHIN 0.04μm OF 50% WV'LN.	.031μm	WITHIN 0.06μm 50% WV'LN.	.0421μm
RESPONSE BETWEEN SW 80% WV'LN. AND LW 80% WV'LN.	80% MIN.	>80%	80% MIN.	>80%

TABLE 5

CHANNEL 1 & 2 SPECTRAL CHARACTERISTICS

AVHRR/201/PFM

	CHANNEL 3		CHANNEL 4	
	SPEC.	MEASURED	SPEC.	MEASURED
SHORTWAVE 50% WV'LN.	10.3±0.09μm	10.362μm	3.55±0.06μm	3.575μm
SW 80% OF 1ST PEAK WV'LN.	SEE SW SLOPE	10.410μm	SEE SW SLOPE	3.592μm
SW 5% WV'LN.	SEE SW SLOPE	10.230μm	SEE SW SLOPE	3.528μm
SW SLOPE	<4.0%	1.7%	<3.0%	1.8%
LONGWAVE 50% WV'LN.	11.3±0.09μm	11.299μm	3.93±0.06μm	3.983μm
LW 80% OF 1ST PEAK WV'LN.	SEE LW SLOPE	10.995μm	SEE LW SLOPE	3.961μm
LW 5% WV'LN.	SEE LW SLOPE	11.470μm	SEE LW SLOPE	4.032μm
LW SLOPE	<4.0%	4.1%	<3.0%	1.8%
RESPONSE BETWEEN SW 80% WV'LN. & LW 80% WV'LN.	80% MIN.	>80%	80% MIN.	>80%
RESPONSE AT WV'LN. <10.0μm AND >12.0μm	≤1%	DID NOT MEAS. OUT OF BAND	N/A	N/A
RESPONSE AT WV'LN. <3.40 m AND >4.12 m	N/A	N/A	≤1%	DID NOT MEAS. OUT OF BAND

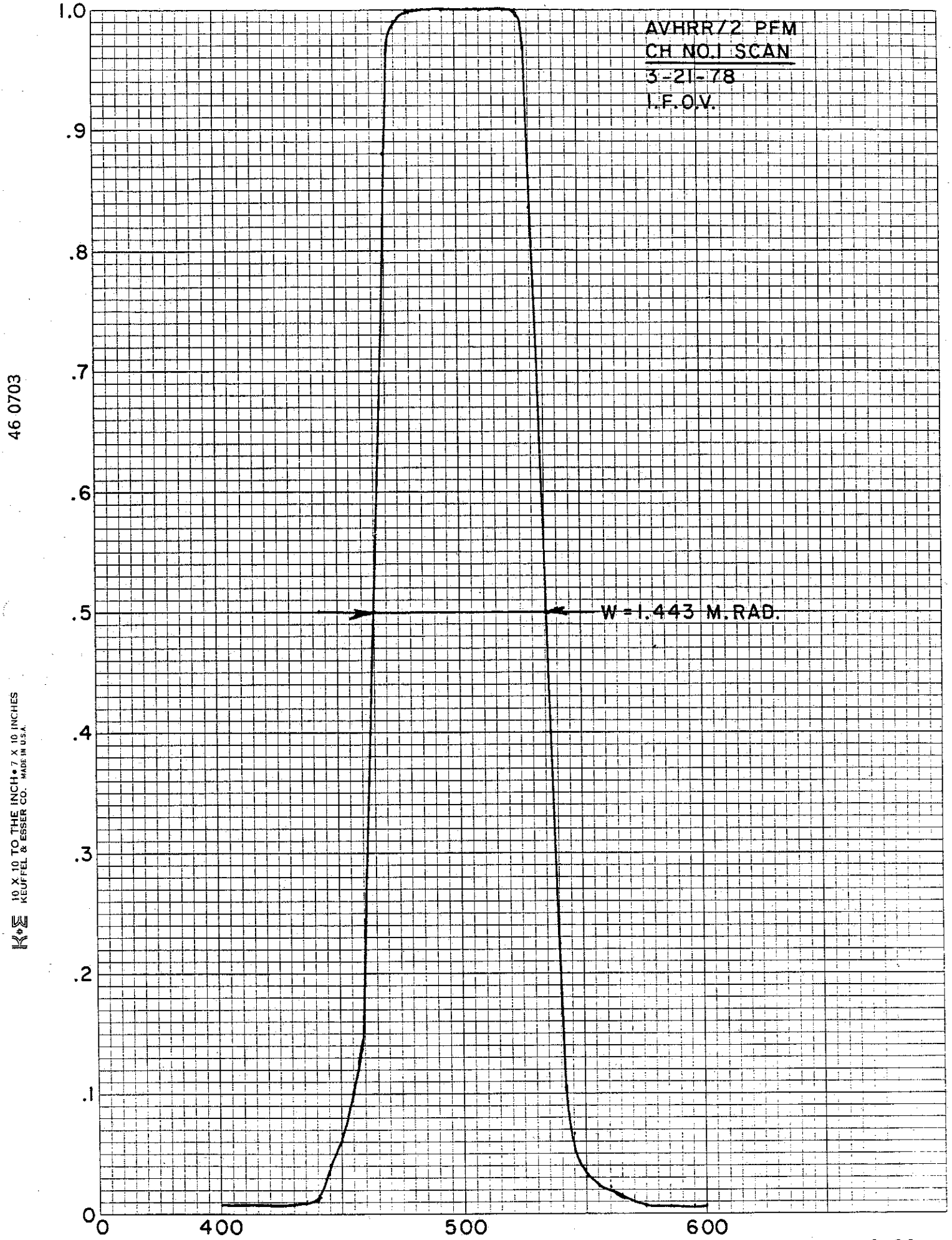
TABLE 6

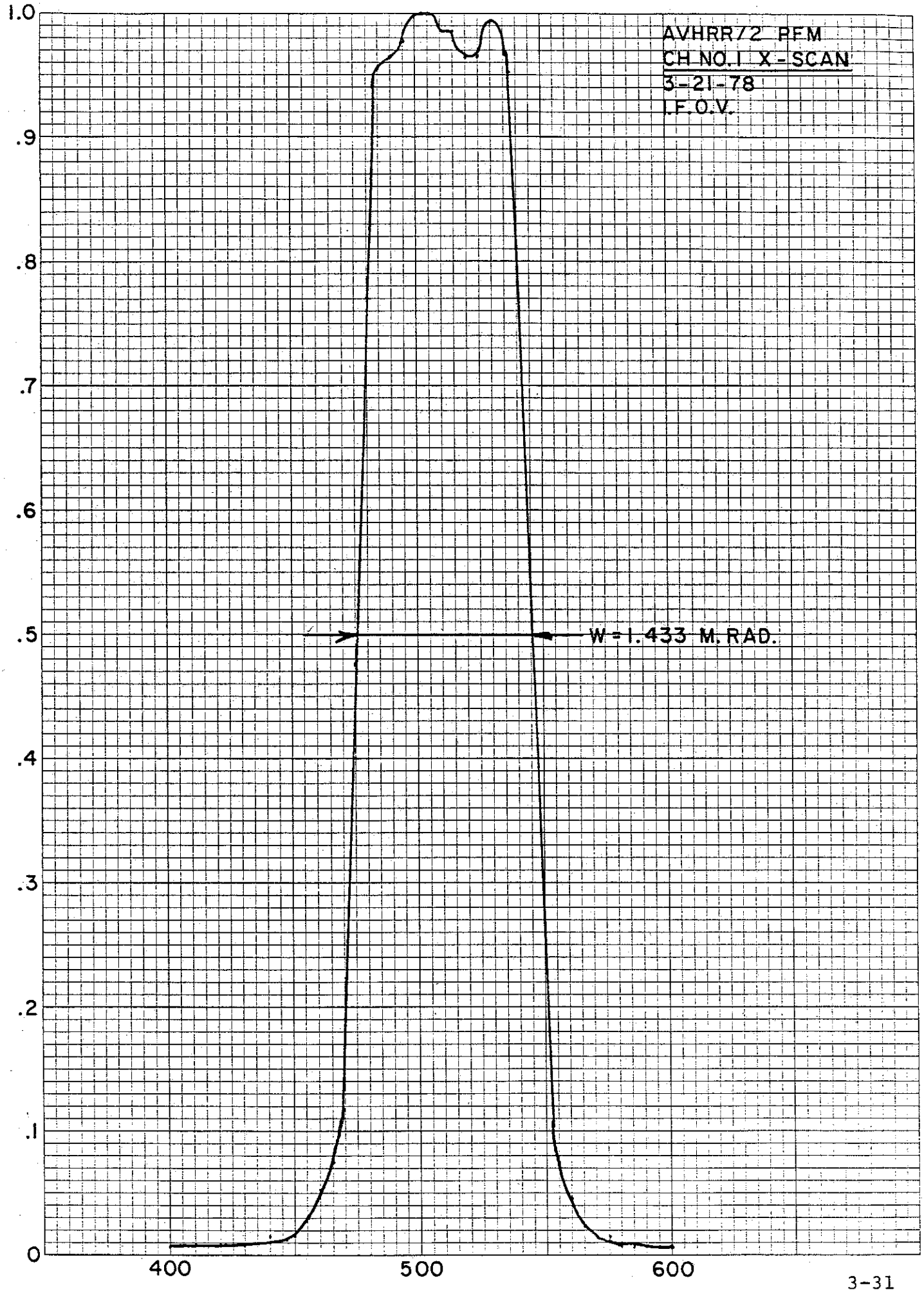
CHANNELS 3 AND 4 SPECTRAL CHARACTERISTICS

	CHANNEL 5	
	SPEC.	MEASURED
SHORTWAVE 50% WV'LN.	11.5±0.09μm	11.450μm
SW 80% OF 1ST PEAK WV'LN.	SEE SW SLOPE	11.500μm
SW 5% WV'LN.	SEE SW SLOPE	11.245μm
SW SLOPE	<4.0%	2.3%
LONGWAVE 50% WV'LN.	12.5±0.09μm	12.424μm
LW 80% OF 1ST PEAK WV'LN.	SEE LW SLOPE	12.145μm
LW 5% WV'LN.	SEE LW SLOPE	12.545μm
LW SLOPE	<4.0%	3.2%
RESPONSE BETWEEN SW 80% WV'LN. & LW 80% WV'LN.	80% MIN	>80%
RESPONSE AT WV'LN. <10.0μm AND >12.0μm	≤1%	DID NOT MEAS. OUT OF BAND

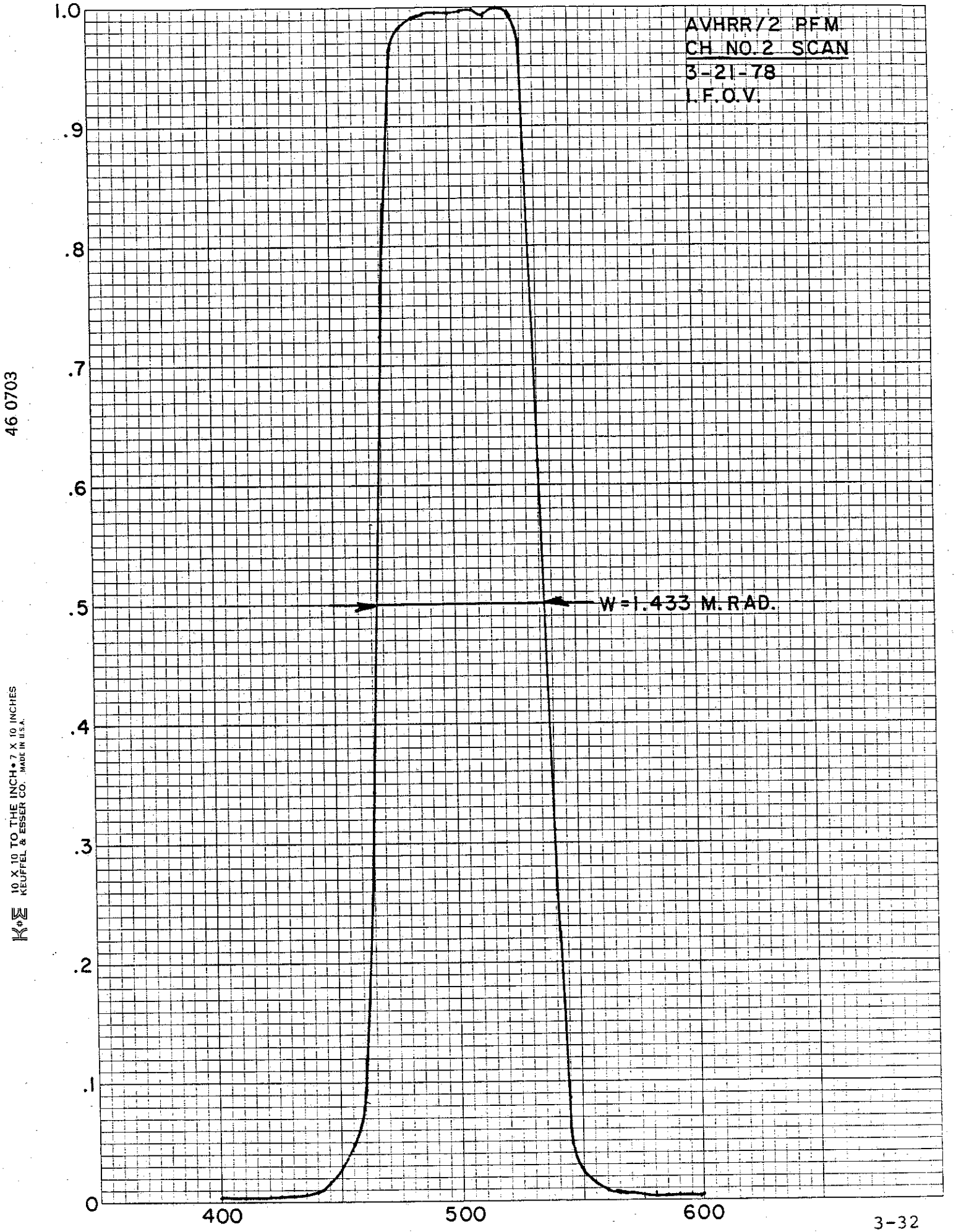
TABLE 7

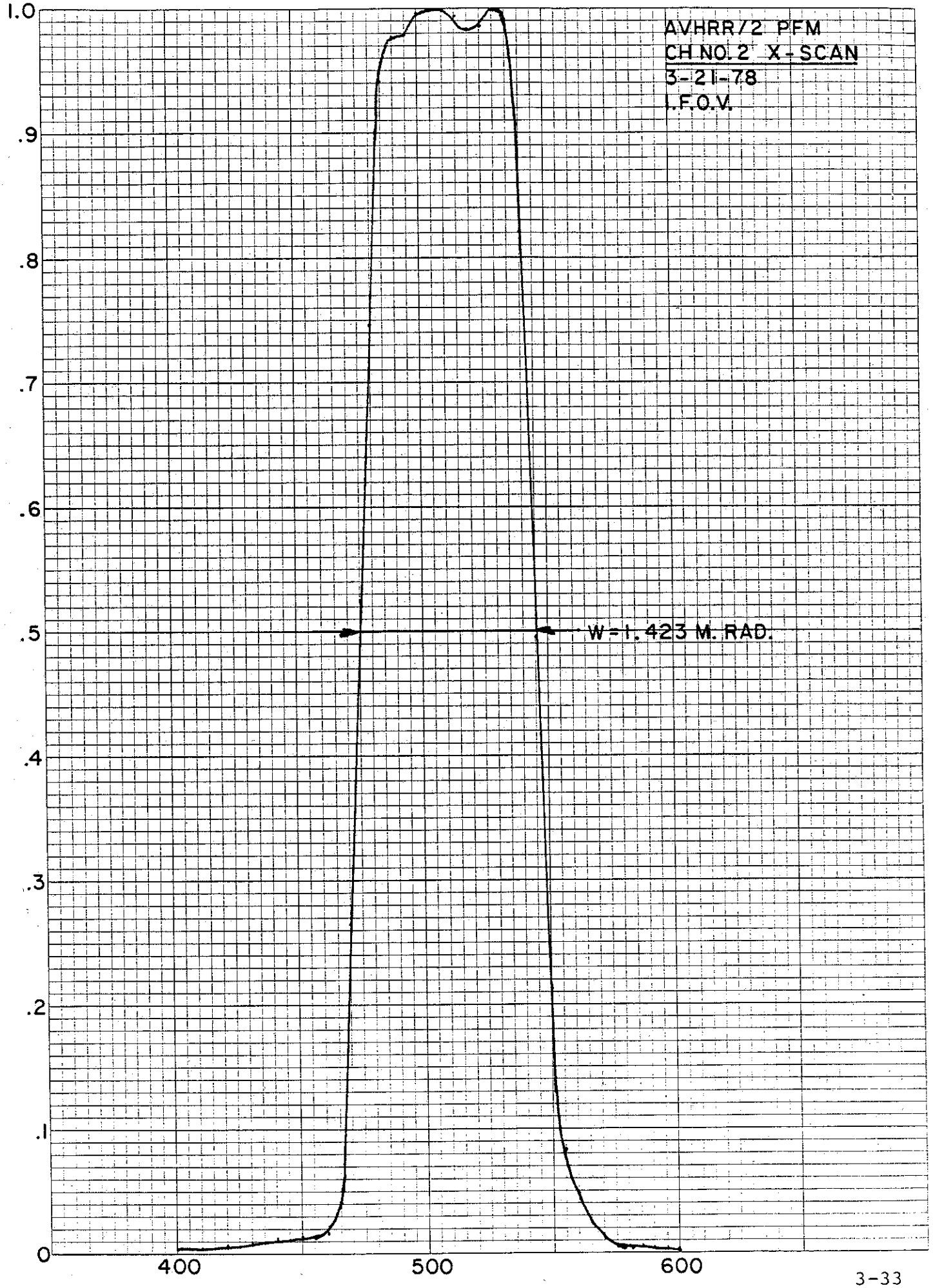
CHANNEL 5 SPECTRAL CHARACTERISTICS


AVHRR/2 PFM
CH NO.1 SCAN
3-21-78
I.F.O.V.
W = 1.443 M.RAD.
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
0
400
500
600
46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

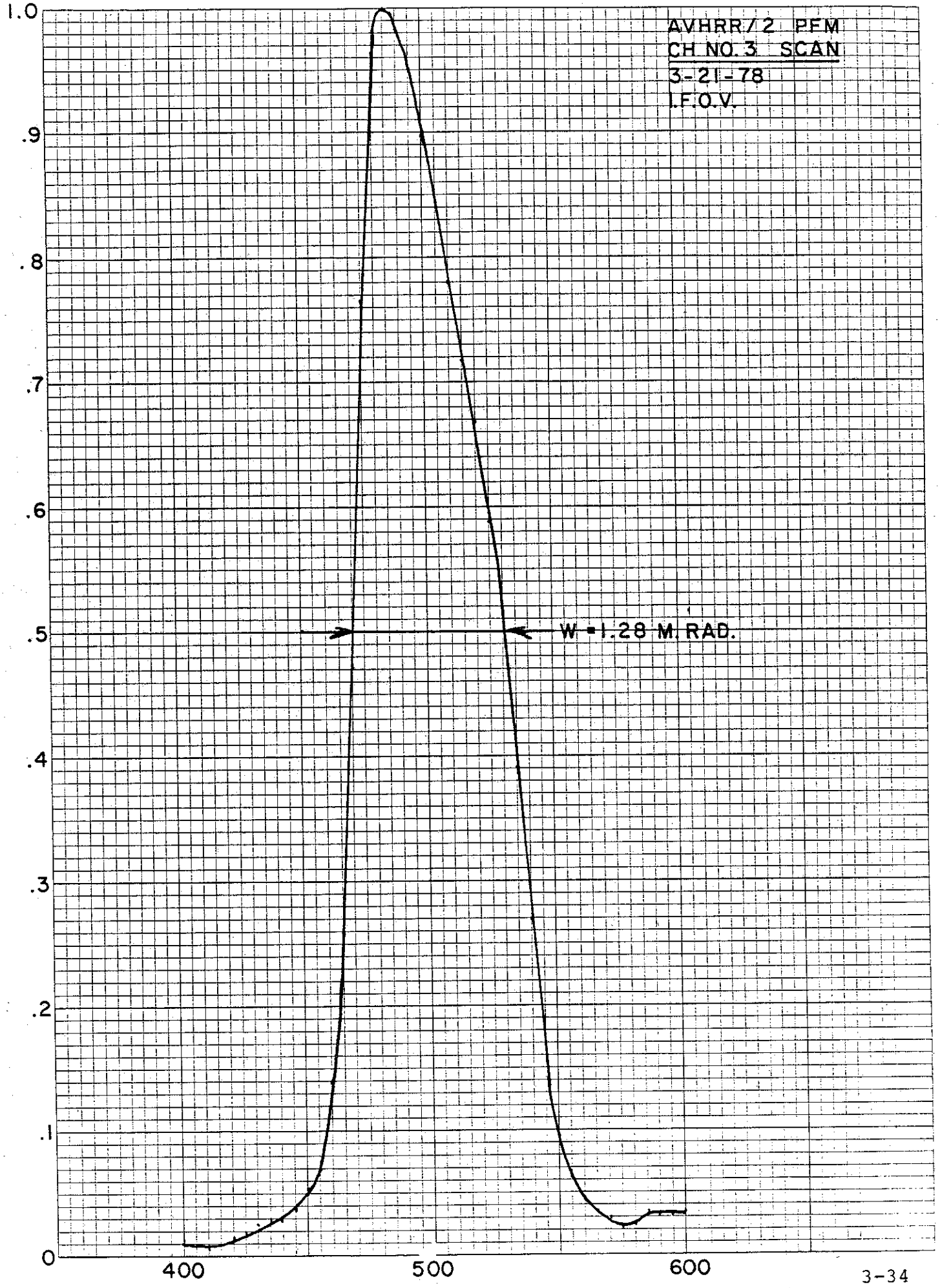


46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.


AVHRR/2 PFM
CH NO. 2 SCAN
3-21-78
I.F.O.V.
W=1.433 M.RAD.
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
400
500
600
46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

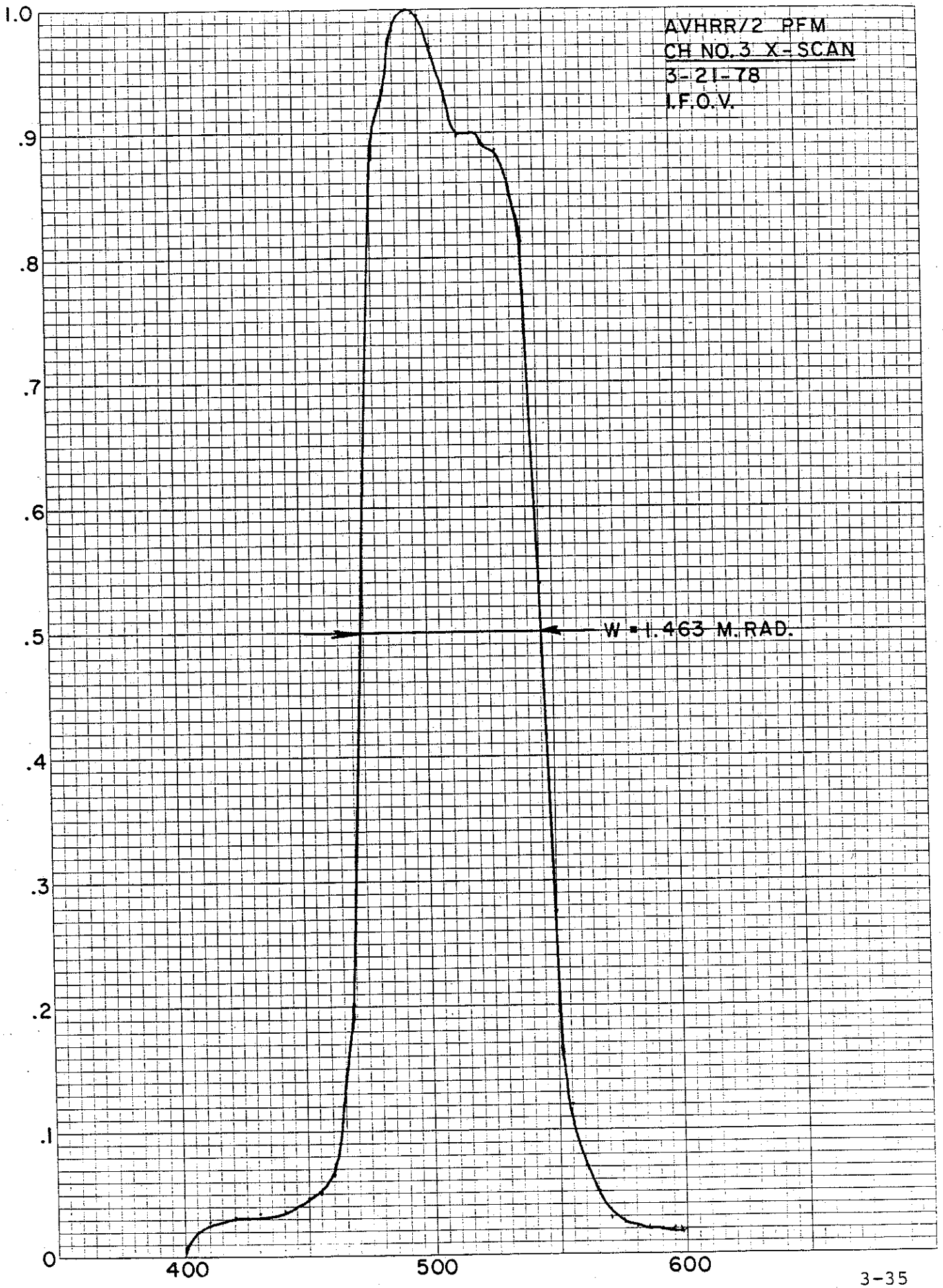


46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



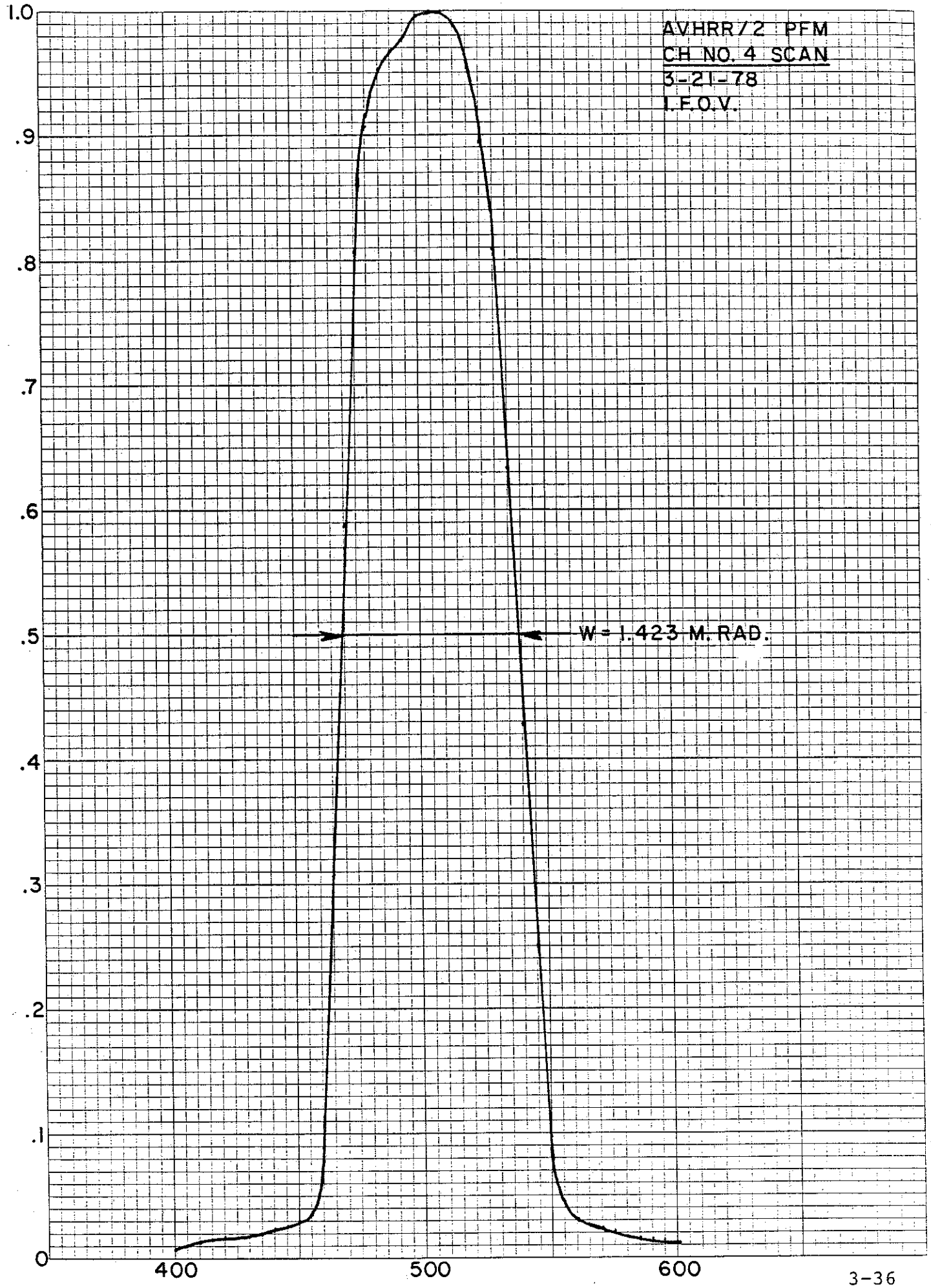
46 0703

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



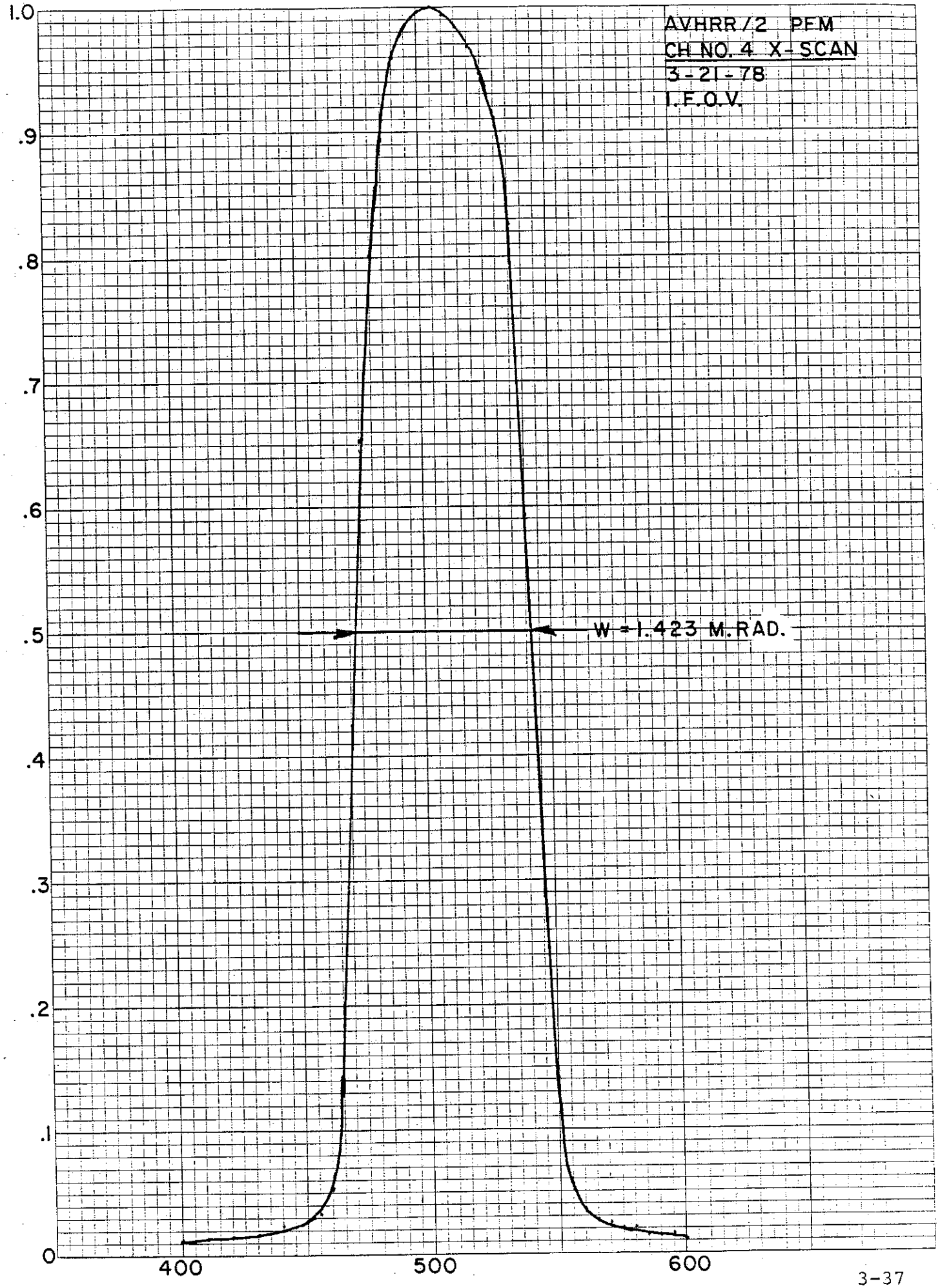
46 0703

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

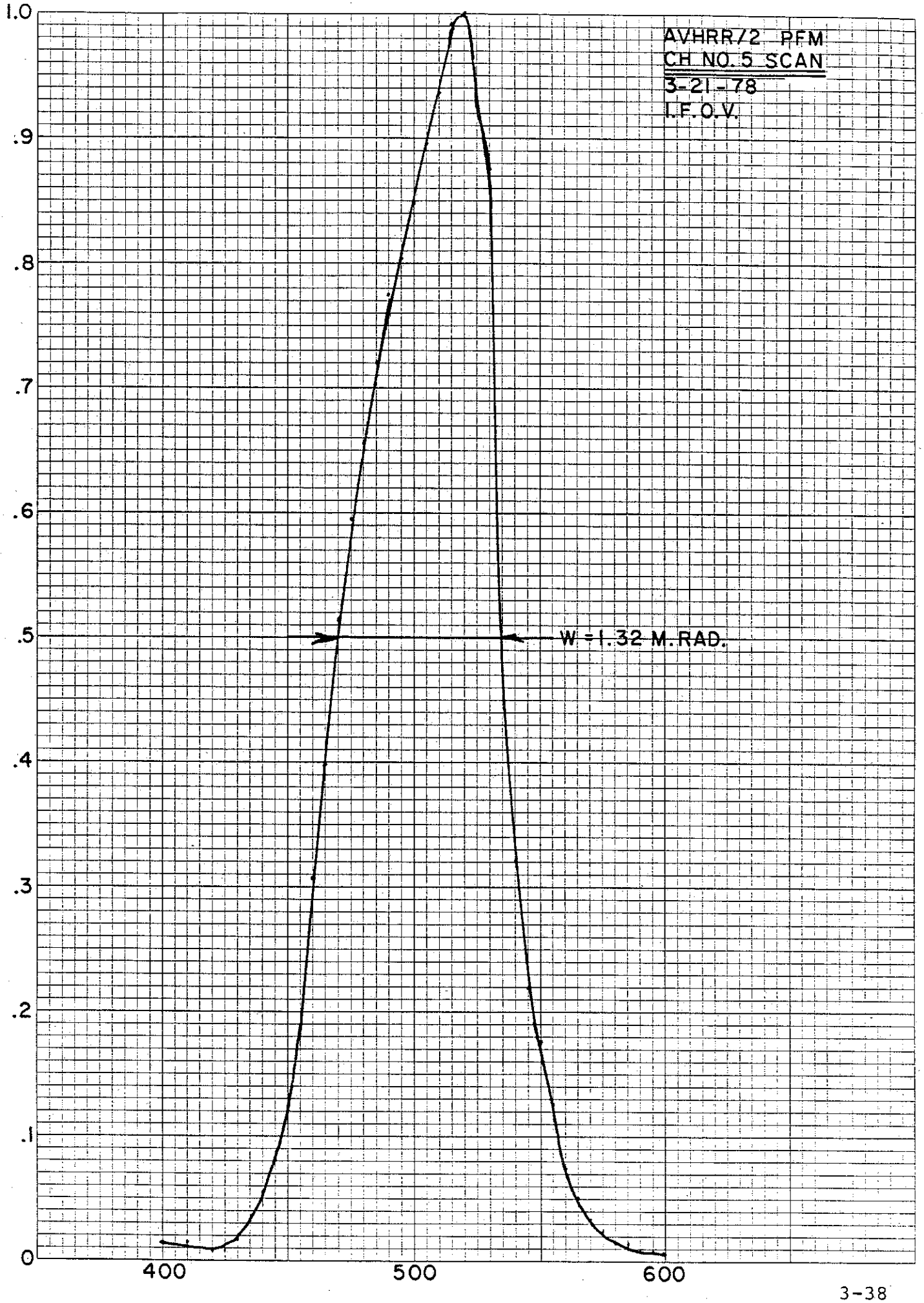


46 0703

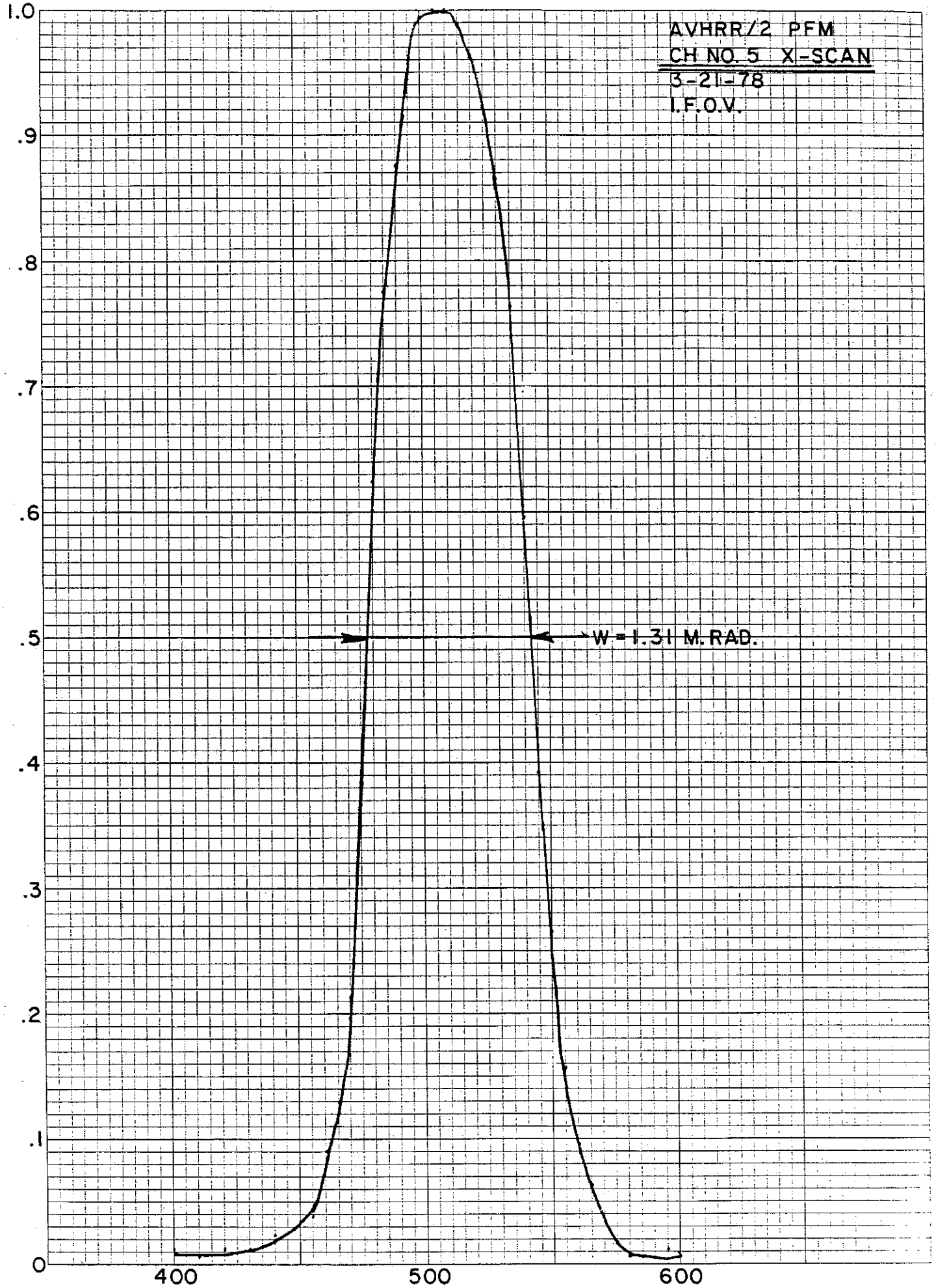
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



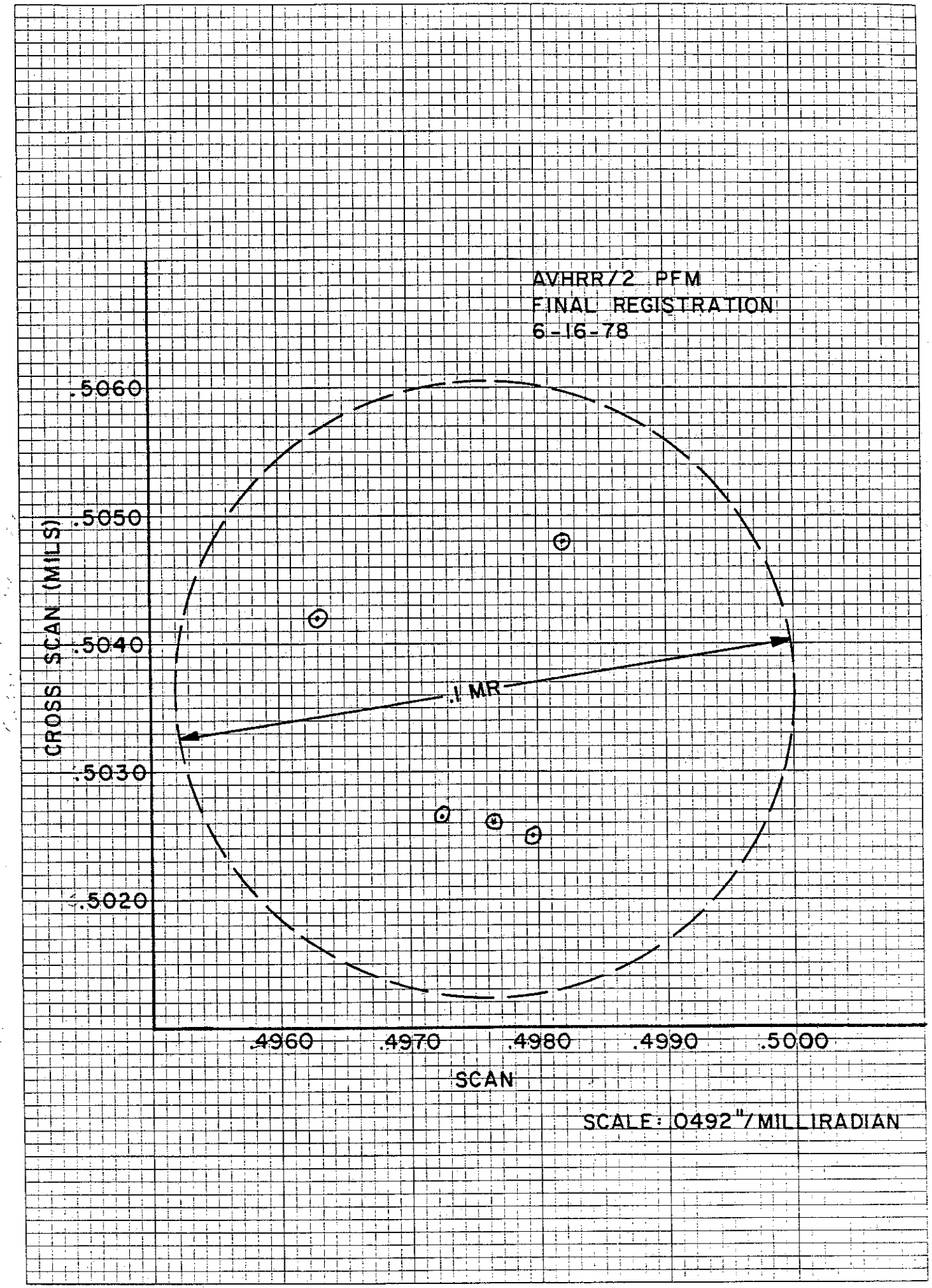
46 0703
K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
K+E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



46 0703
10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

AVHRR/2 SYSTEM MTF

TARGET SPATIAL FREQ.	CH 1		CH 2		CH 3		CH 4		CH 5	
	SCAN	X-SCAN	SCAN	X-SCAN	SCAN	X-SCAN	SCAN	X-SCAN	SCAN	X-SCAN
385C/R	44.3%	44.1%	45.2%	46.2%	48.7%	41.7%	49.3%	49.2%	36.6%	40.5%
258	82.9	85.3	82.1	87.2	87.5	83.3	84.8	88.8	80.5	81.0
192	97.1	97	100	98.7	100	100	97.1	98.4	97.6	97.3
19.2	100	100	100	100	100	100	99.3	98.4	100	100
0	100	100	100	100	100	100	100	100	100	100

FIGURE 3.7.1

4.0 FINAL BENCH CHECK DATA

This section contains detailed information in support of calibration and alignment data supplied in Section 3.0 of this report. Data in this section has been taken from completed test procedures, computer printouts, etc. Backup calibration calculations are included where necessary.

4.1 Scan Plane Alignment/Mounting

The backup alignment data for instrument alignment is included with the data presented in Section 2.0. The data presented in Section 2.3 relates the instrument scanned plane to its mounting surface. With this information, the AVHRR/2 can be aligned on the S/C.

4.2 Visible Channel Calibration (Channels 1 & 2)

Table 4.2.1 is a tabulation of the visible channel calibration data used to plot the graphs in Section 3.1. This table presents instrument output vs the number of integrating sphere lamps. A calculation of percent albedo is also included for each equivalent lamp output. Table 4.2.2 is a tabulation at data indicating the linearity of the visible channels compared to the integrating sphere output. Table 4.2.3 is a summary of the visible channels outputs including the resultant noise level in each channel.

4.3 IR Channels Calibration (CHs 3, 4 & 5)

The graphs presented in Section 3.2 were plotted from data taken from computer printouts and presented in Tables 4.3-1 through 5 of this section. These tables indicate instrument output in Channels 3, 4 & 5 vs calibration black body target temperature and represent 3600 data samples per reading. The NEΔT measurement is included below each table. Table 4.3.6 is a chart of the instrument output in Channels 3, 4 & 5 vs the in-flight calibrated black body temperature. The values of the in-flight calibration BB were taken from telemetry data as it appears in the digital output data stream and converted using the equations as presented in Section 3.0. These points are plotted on the graphs presented in Section 3.2.1.

	CHANNEL #1						CHANNEL #2					
NO. AMPS	% ALBEDO	SIGNAL MV	CNTS.	STD.DEV MV	SPACE SIGNAL MV	SPACE STD.DEV MV	% ALBEDO	SIGNAL MV	CNTS.	STD.DEV MV	SPACE SIGNAL MV	SPACE STD.DEV MV
12	79.10	4841.59	775	2.887	235.27	2.935						
11	72.51	4445.53	711	2.751	235.17	2.953						
10	65.92	4068.29	651	1.749	234.98	2.979						
9	59.33	3686.77	590	2.304	234.75	3.044						
8	52.73	3282.03	525	2.144	234.82	2.965						
7	46.14	2888.45	462	2.161	234.58	2.925						
6	39.55	2506.09	401	1.033	234.53	2.849	93.13	5658.24	905	2.207	247.29	3.000
5	32.96	2125.29	340	1.373	234.42	2.913	77.61	4748.49	760	2.122	247.48	2.991
4	26.37	1749.73	280	1.121	234.32	3.050	62.09	3850.44	616	1.526	247.36	3.004
3	19.78	1347.69	216	2.642	234.72	2.954	46.57	2908.53	465	1.729	247.57	2.976
2	13.18	962.91	154	1.756	234.67	2.898	31.04	1999.61	320	1.462	247.43	2.996
1	6.59	577.62	92	2.967	234.75	3.022	15.52	1081.39	173	.907	247.36	2.999
0	0	237.42	38	.934	234.70	3.034	0	247.44	40	2.952	247.22	2.971

DATE: 6/19/78

MODEL: AVHRR/2 PFM

TABLE 4.2.1

SOLAR CHANNELS CALIBRATION DATA

NO. LAMPS	% ALBEDO	CHAN 1 SIGNAL	CORRECTED SIGNAL	MEASURED RATIO	SPHERE RATIO	DIFFERENCE
12	79.10%	4841.59	4606.32	1.0000	1.000	-
11	72.51%	4445.53	4210.36	.9140	.9154	-.0014
10	65.92%	4068.29	3833.31	.8322	.8334	-.0012
9	59.33%	3686.77	3452.02	.7494	.7504	-.0010
8	52.73%	3282.03	3047.21	.6615	.6647	-.0032
7	46.14%	2888.45	2653.87	.5761	.5801	-.0040
6	39.55%	2506.09	2271.56	.4931	.4949	-.0018
5	32.96%	2125.29	1890.87	.4105	.4130	-.0025
4	26.37%	1749.73	1515.41	.3290	.3342	-.0052
3	19.78%	1347.69	1112.97	.2416	.2475	-.0059
2	13.18%	962.91	728.24	.1581	.1628	-.0047
1	6.59%	577.62	342.87	.0744	.0798	-.0054
0	0%	237.42	-0-	-0-	-0-	-0-

NO. LAMPS	% ALBEDO	CHAN 1 SIGNAL	CORRECTED SIGNAL	MEASURED RATIO	SPHERE RATIO	DIFFERENCE
6	93.13%	5658.24	5410.80	1.0000	1.000	-
5	77.61%	4748.49	4501.05	.8319	.8345	-.0026
4	62.09%	3850.44	3603.00	.6659	.6753	-.0094
3	46.57%	2908.53	2661.09	.4918	.5001	-.0083
2	31.04%	1999.61	1752.17	.3238	.3290	-.0052
1	15.52%	1081.39	833.95	.1541	.1612	-.0071
0	0%	247.44	-0-	-0-	-0-	-0-

DATE: 6/19/78

MODEL: AVHRR/2 PFM

FIGURE 4.2.2

SOLAR CHANNEL RADIANCE LINEARITY

SUMMARY SHEET

	MEASURED	SPECIFIED
CHANNEL 1-12 LAMP SIGNAL	4841.59mv	CALC. 4.825V ±79mv
CHANNEL 2-6 LAMP SIGNAL	5658.24mv	CALC. 5.681V ±93mv
CHANNEL 1 ZERO LEVEL SIGNAL	237.42	0.250 ±.050V
CHANNEL 2 ZERO LEVEL SIGNAL	247.44	0.250 ±.050V
CALCULATED CHANNEL 1 NOISE	2.963mv	10.0mv MAXIMUM
CALCULATED CHANNEL 2 NOISE	2.991mv	10.0mv MAXIMUM

DATE 6/19/78

MODEL AVHRR/2 PFM

FIGURE 4.2.3

CHANNELS 1 AND 2 CALIBRATION AND NOISE

TARGET TEMPERATURE	SIGNAL LEVEL OUTPUT					
	CHANNEL 3	CNTS.	CHANNEL 4	CNTS.	CHANNEL 5	CNTS.
174.80°K	6018.53 mv	963	6213.23mv	994	5923.68mv	948
184.90	5912.11	946	6215.95	994	5802.44	928
195.05	5773.07	924	6210.21	994	5650.29	904
205.05	5595.57	895	6203.70	993	5459.66	874
215.05	5376.83	860	6191.38	991	5228.83	837
225.15	5110.31	818	6173.08	988	4956.84	793
235.00	4810.27	770	6134.57	981	4650.35	744
245.05	4432.88	709	6056.22	969	4281.71	685
255.05	4020.75	643	5922.69	948	3879.32	621
265.00	3556.65	569	5710.23	914	3434.66	550
275.05	3033.83	485	5355.32	857	2942.85	471
285.00	2472.87	396	4831.47	773	2410.69	386
295.05	1856.31	297	4030.92	645	1838.91	294
305.00	1195.32	191	2882.23	461	1224.47	196
315.00	489.42	78	1258.00	201	569.88	91
320.05	117.24	19	222.34	36	223.38	36
SPACE CLAMP	6201.80	992	6215.26	994	6195.09	991

$$NE\Delta T\ (300^{\circ}K) = \frac{NOISE}{SLOPE} \begin{cases} = \dfrac{2.63mv}{66.43mv/K} = \underline{\underline{.039K}}(CH\ \#3) \\ = \dfrac{6.93mv}{115.45mv/K} = \underline{\underline{.060K}}(CH\ \#4) \\ = \dfrac{2.81mv}{61.75mv/K} = \underline{\underline{.045K}}(CH\ \#5) \end{cases}$$

TABLE 4.3.1

RADIANCE CALIBRATION CHANNELS 3, 4 & 5 (BP10°C)

AVHRR/2

TARGET TEMPERATURE	SIGNAL LEVEL OUTPUT					
	CHANNEL 3	CNTS.	CHANNEL 4	CNTS.	CHANNEL 5	CNTS.
175.05°K	6018.23mv	963	6212.86mv	994	5921.48mv	947
185.05	5912.45	946	6213.28	994	5799.80	928
204.95	5604.00	897	6200.85	992	5461.75	874
224.90	5123.96	820	6169.47	987	4963.15	794
234.90	4814.38	770	6130.08	981	4645.85	743
245.00	4449.58	712	6053.97	969	4285.06	686
254.95	4036.92	646	5921.05	947	3882.19	621
265.00	3573.29	572	5701.60	912	3435.60	550
275.00	3051.86	488	5343.97	855	2944.10	471
285.05	2486.88	398	4800.02	768	2405.37	385
295.00	1879.41	301	3992.76	639	1833.73	293
300.05	1544.27	247	3452.97	552	1522.66	244
305.05	1211.96	194	2820.20	451	1209.91	194
310.10	859.66	138	2050.38	328	885.28	142
315.05	505.60	81	1156.09	185	556.15	89
320.05	137.70	22	115.83	19	214.70	34
SPACE CLAMP	6201.86	992	6212.52	994	6195.20	991

$$NE\Delta T\ (300^{\circ}K) = \frac{NOISE}{SLOPE} \begin{cases} = \dfrac{1.71mv}{66.41mv/K} = \underline{\underline{.026K}} & (CH\ \#3) \\ = \dfrac{6.64mv}{116.67mv/K} = \underline{\underline{.057K}} & (CH\ \#4) \\ = \dfrac{3.16mv}{62.07mv/K} = \underline{\underline{.05K}} & (CH\ \#5) \end{cases}$$

TABLE 4.3.2

RADIANCE CALIBRATION CHANNELS 3, 4 & 5 (BP15°C)

AVHRR/2

TARGET TEMPERATURE	SIGNAL LEVEL OUTPUT					
	CHANNEL 3	CNTS.	CHANNEL 4	CNTS	CHANNEL 5	CNTS.
175.05°K	6019.82mv	963	6207.28mv	993	5920.39mv	947
185.05	5915.33	946	6209.21	993	5799.79	928
205.05	5607.72	897	6197.08	992	5460.02	874
225.05	5131.35	821	6164.92	986	4964.26	794
235.10	4825.22	772	6127.28	980	4647.02	744
245.05	4466.11	715	6048.77	968	4291.59	687
255.05	4056.08	649	5915.71	947	3889.66	622
265.00	3597.96	576	5695.48	911	3444.62	551
275.00	3081.34	493	5335.58	854	2956.33	473
284.95	2527.19	404	4800.70	768	2424.97	388
295.00	1913.72	306	3981.69	637	1845.87	295
300.00	1587.28	254	3445.12	551	1542.29	247
305.00	1255.78	201	2804.05	449	1226.56	196
310.05	907.25	145	2036.75	326	905.35	145
315.05	551.70	88	1129.74	181	572.15	92
320.00	186.93	30	79.14	13	230.19	37
SPACE CLAMP	6201.73	992	6208.97	993	6195.05	991

$$NE\Delta T\ (300^{\circ}K) = \frac{NOISE}{SLOPE}\begin{cases} = \dfrac{1.60mv}{65.79mv/K} = \underline{\underline{.024K}}\ (CH\ \#3) \\ = \dfrac{6.88mv}{117.76mv/K} = \underline{\underline{.058K}}\ (CH\ \#4) \\ = \dfrac{3.01mv}{61.93mv/K} = \underline{\underline{.048K}}\ (CH\ \#5) \end{cases}$$

TABLE 4.3.3

RADIANCE CALIBRATION CHANNELS 3, 4 & 5 (BP20°C)

AVHRR/2

TARGET TEMPERATURE	SIGNAL LEVEL OUTPUT					
	CHANNEL 3	CNTS.	CHANNEL 4	CNTS.	CHANNEL 5	CNTS.
174.95°K	6021.11 mv	963	6204.95mv	993	5918.91mv	947
185.00	5917.60	947	6204.56	993	5798.80	928
205.05	5611.56	898	6195.65	991	5457.85	873
225.00	5139.64	822	6163.43	986	4963.03	794
235.00	4837.54	774	6124.45	980	4649.62	744
245.05	4476.89	716	6045.39	967	4291.52	687
255.05	4073.87	652	5910.50	946	3891.89	623
265.00	3623.16	580	5691.03	911	3453.68	553
274.95	3107.76	497	5327.81	852	2961.27	474
285.10	2550.00	408	4771.66	763	2425.08	388
295.00	1950.64	312	3960.67	634	1856.76	297
300.15	1625.16	260	3406.88	545	1544.94	247
305.05	1296.98	208	2764.90	442	1241.55	199
310.00	956.55	153	2005.60	321	921.41	147
314.95	603.02	96	1086.63	174	589.38	94
320.05	231.89	37	19.62	3	243.12	39
SPACE CLAMP	6201.34	992	6206.72	993	6194.96	991

$$NE\Delta T\ (300^{\circ}K) = \frac{NOISE}{SLOPE} \begin{cases} = \dfrac{2.99mv}{65.04mv/K} = \underline{\underline{.046K}}\ (CH\ \#3) \\ = \dfrac{6.59mv}{118.98mv/K} = \underline{\underline{.055K}}\ (CH\ \#4) \\ = \dfrac{3.05mv}{61.21mv/K} = \underline{\underline{.05K}}\ (CH\ \#5) \end{cases}$$

TABLE 4.3.4

RADIANCE CALIBRATION CHANNEL 3, 4 & 5 (BP25°C)

AVHRR/2

TARGET TEMPERATURE	SIGNAL LEVEL OUTPUT					
	CHANNEL 3	CNTS.	CHANNEL 4	CNTS.	CHANNEL 5	CNTS.
175.05°K	6024.12mv	964	6202.61mv	992	5918.88mv	947
185.00	5921.60	947	6202.19	992	5799.46	928
205.00	5636.58	902	6192.95	991	5480.31	877
225.00	5150.80	824	6160.88	986	4964.49	794
235.05	4850.33	776	6120.79	979	4652.14	744
245.05	4493.13	719	6039.02	966	4294.24	687
255.05	4093.54	655	5901.27	944	3898.89	624
265.00	3645.45	583	5680.15	909	3458.51	553
275.10	3134.57	501	5314.38	850	2967.59	475
285.00	2587.07	415	4758.64	761	2440.10	390
295.00	1993.96	319	3940.29	630	1873.09	300
300.05	****		****		****	
305.05	1337.32	214	2733.92	437	1255.77	201
310.05	998.84	160	1954.70	313	931.36	149
315.00	649.94	104	1044.30	167	604.48	97
320.00	289.81	46	6.04	1.0	267.29	43
SPACE CLAMP	6201.37	992	6200.94	992	6195.04	991

$$NE\Delta T\ (300^{\circ}K) = \frac{NOISE}{SLOPE} \begin{cases} = \dfrac{1.14mv}{65.33mv/K} = \underline{\underline{.017K}}\ (CH\ \#3) \\ = \dfrac{6.26mv}{120.04mv/K} = \underline{\underline{.052K}}\ (CH\ \#4) \\ = \dfrac{2.18mv}{61.43mv/K} = \underline{\underline{.035K}}\ (CH\ \#5) \end{cases}$$

****BAD DATA

TABLE 4.3.5

RADIANCE CALIBRATION CHANNELS 3, 4 & 5 (BP30°C)

AVHRR/2

B.P. TEMP	IN-FLIGHT CAL. TGT. MEAN						B.B. TM#1		B.B. TM#2		B.B. TM#3		B.B. TM#4		AVG. B.B TEMP °K
	CH #3		CH #4		CH #5		OUT V	°C*	OUT V	°C*	OUT V	°C*	OUT V	°C*	
	mv	CNT	mv	CNT	mv	CNT									
10°C	2558.42	425	5023.64	804	2587.14	414	.600	8.37	.631	8.63	.618	8.52	.700	9.19	281.83
15°C	2379.90	381	4669.91	747	2300.71	368	1.231	13.59	1.262	13.85	1.244	13.69	1.319	14.32	287.01
20°C	2122.62	340	4286.07	686	2043.93	327	1.800	18.32	1.843	18.68	1.812	18.42	1.881	18.99	291.75
25°C	1853.11	296	3805.09	609	1765.47	282	2.381	23.17	2.425	23.54	2.394	23.27	2.456	23.79	296.59
30°C	1570.31	251	3210.76	514	1476.33	236	2.975	28.15	3.012	28.47	2.981	28.21	3.044	28.73	301.54

* See Telemetry Calibration Table for Equation.

TABLE 4.3.6

IN-FLIGHT BLACK BODY TM

CALIBRATION

4.4 Spectral Calibration

The graphs presented in Section 3.2 were plotted from the following spectral data. Tables 4.4-1 through 4.4-5 are tabulations of the measured spectral response of the five instrument channels.

4.5 IFOV Characteristics

The graphs presented in Section 3.5 were plotted from the data presented in Tables 4.5-1 and 4.5-2. This is a tabulation of the normalized output of the five data channels versus the position of a (.1 IFOV) slit target in the focal plane of the test collimator.

Tables 4.5-3 and 4.5-4 are tabulations of registration and IFOV width taken from the same data. The conversion factor for width is 49.2 mils per milliradian of the collimator focal point.

4.6 MTF Data

Table 4.6-1 is a tabulation of the visible channel MTF data and Table 4.6-2, the IR channels.

DATA MEASURED RESPONSE (CH #1)

WVLN	SIGNAL AMP. REF.	SIGNAL AMP. CH #1	CH #1 / REF.	MIRROR REFLECTANCE	RELATIVE SPECTRAL RESPONSE	NORMAL RESPONSE
500	4.20mv	0.00mv	0	.810	0	0
510	4.83	1.0	.207	.806E	.26	.0032
520	5.15	1.0	.194	.802	.24	.0030
530	5.65	1.0	.177	.800E	.22	.0028
540	6.33	1.0	.158	.797	.20	.0025
550	6.74	2.0	.297	.795E	.373	.0047
560	6.99	45	6.44	.794	8.11	.101
570	7.22	217	30.0	.792E	37.9	.474
580	7.46	340	45.6	.790	57.7	.723
590	7.54	373	49.5	.788E	62.8	.787
600	7.71	375	48.6	.786	61.8	.774
610	7.80	387	49.6	.783E	63.3	.793
620	7.86	422	53.7	.781	68.7	.861
630	7.40	460	62.2	.779E	79.8	1.000
640	7.78	456	58.6	.777	75.4	.944
650	7.50	437	58.3	.775E	75.2	.942
660	7.54	442	58.6	.772	75.9	.951
670	7.36	441	59.9	.768E	78.0	.977
680	6.94	306	44.1	.764	57.7	.723
690	6.65	140	21.0	.762E	27.6	.345
700	6.75	60	8.89	.759	11.7	.147
710	6.77	29	4.28	.753E	5.68	.071
720	6.25	16	2.56	.753	3.40	.042
730	6.20	10	1.61	.748E	2.15	.027
740	5.95	6	1.01	.743	1.36	.017
750	5.78	4	.69	.739E	.93	.012
760	5.40	3	.56	.734	.76	.0095
770	5.07	3	.59	.732E	.81	.010
780	4.74	3	.63	.731	.86	.011
790	4.62	2	.43	.726E	.59	.007
800	4.52	0	0	.722	0	0

TABLE 4.4-1

CHANNEL 1 SPECTRAL RESPONSE

DATA MEASURED RESPONSE (CH #2)

WVLN	SIGNAL AMP. REF.	SIGNAL AMP. CH #2	CH #2 / REF.	MIRROR REFLECTANCE	RELATIVE SPECTRAL RESPONSE	NORMAL RESPONSE
600	.54mv	2.0mv	3.7	.786	4.7	.038
610	.69	2.0	2.9	.783E	3.7	.030
620	.82	2.0	2.4	.781	3.1	.025
630	1.00	1.0	1	.779E	1.3	.010
640	1.17	0	∿0	.777	∿0	∿0
650	1.36	1.0	.7	.775E	.90	.007
660	1.68	1.0	.6	.772	.78	.006
670	1.91	1.0	.5	.768E	.65	.005
680	2.19	1.0	.5	.764	.65	.005
690	2.39	2.0	.84	.762E	1.1	.009
700	2.73	26	9.5	.759	12.5	.101
710	2.99	115	38.5	.756E	50.9	.412
720	3.21	219	68.2	.753	90.6	.733
730	3.40	285	83.8	.748E	112.0	.907
740	3.63	322	88.7	.743	119.4	.966
750	3.82	346	90.6	.739E	122.6	.992
760	3.97	360	90.7	.734	123.6	1.00
770	4.12	367	89.1	.732E	121.7	.985
780	4.07	365	89.7	.731	122.7	.993
790	4.30	358	83.2	.727E	114.4	.926
800	4.19	352	84.0	.722	116.3	.941
810	4.27	352	82.4	.720E	114.4	.926
820	4.67	360	77.1	.717	107.5	.870
830	4.82	372	77.2	.718E	107.5	.870
840	5.06	391	77.3	.718	107.7	.871
850	5.44	425	78.1	.726E	107.6	.870
860	5.94	472	79.5	.734	108.3	.876
870	6.59	527	80.0	.746E	107.2	.868
880	7.34	598	81.5	.756	107.8	.872
890	8.13	660	81.2	.765E	106.1	.859
900	8.46	684	80.8	.774	104.4	.845
910	9.04	729	80.6	.780E	103.3	.836
920	9.92	794	80.0	.787	101.6	.823
930	11.3	877	77.6	.796E	97.5	.789
940	12.6	980	77.8	.805	96.6	.782
950	14.1	1092	77.4	.813E	95.2	.770
960	15.5	1201	77.5	.822	94.3	.763
970	16.6	1236	74.5	.827E	90.1	.729
980	17.8	1114	62.6	.833	75.1	.608
990	18.8	827	44.0	.838E	52.5	.425

TABLE 4.9.2 SH. 1

CHANNEL 2 SPECTRAL RESPONSE

DATA MEASURED RESPONSE (CH #2)

WVLN	SIGNAL AMP. REF.	SIGNAL AMP. CH #2	CH #2 / REF.	MIRROR REFLECTANCE	RELATIVE SPECTRAL RESPONSE	NORMAL RESPONSE
1000	19.7	514	26.1	.843	31.0	.250
1010	20.6	292	14.2	.848E	16.7	.136
1020	21.4	165	7.7	.852	9.0	.073
1030	22.1	96	4.3	.858E	5.0	.040
1040	22.8	57	2.5	.865	2.9	.023
1050	23.6	35	1.5	.870E	1.7	.014
1060	24.3	22	.91	.875	1.0	.008
1070	25.1	16	.64	.878E	.73	.006
1080	25.6	12	.47	.880	.53	.004
1090	26.1	10	.38	.860E	.44	.0036
1100	26.5	8	.38	.840	.45	.0037
1120	26.9	7	.26	.840E	.31	.0025
1160	∿27	5	∿.18	.840E	∿.22	∿.0018

TABLE 4.9.2 SH. 2

CHANNEL 2 SPECTRAL RESPONSE

DATA MEASURED RESPONSE (CH #~~3~~ 4)

WVLN	REF. SIG.	CH. SIG.	RELATIVE RESPONSE	NORMAL RESPONSE
10.00	4.38mv	2 mv	.5	<.004
10.10	4.28	7	1.6	.004
10.15	4.08	16.5	4.0	.0095
10.20	3.95	43	10.9	.026
10.25	3.85	129	33.5	.079
10.30	3.78	338	89.4	.212
10.35	3.55	682	192	.456
10.400	5.55	1073	193	.748
10.425	5.51	1218	221	.856
10.450	5.33	1310	246	.953
10.475	5.28	1344	254	.984
10.500	5.15	1330	258	1.000
10.525	5.12	1304	255	.988
10.550	5.03	1268	252	.977
10.575	4.99	1238	248	.961
10.600	4.92	1213	246	.953
10.625	4.89	1193	244	.946
10.650	4.85	1180	243	.943
10.675	4.83	1174	243	.943
10.700	4.78	1167	244	.946
10.725	4.72	1154	244	.946
10.750	4.69	1138	244	.946
10.775	4.65	1123	241	.936
10.800	4.61	1100	239	.925
10.825	4.59	1070	233	.903
10.850	4.56	1040	228	.884
10.875	4.52	1013	224	.869
10.900	4.50	987	219	.850
10.925	4.44	963	217	.841
10.950	4.44	940	212	.821
10.975	4.43	923	208	.807
11.000	4.41	908	206	.798
11.025	4.46	891	200	.774
11.050	4.40	872	198	.768
11.075	4.45	850	191	.740
11.100	4.37	827	189	.733
11.125	4.30	799	186	.720
11.150	4.38	772	176	.683

TABLE 4.4.3 SH. 1

CHANNEL 3 SPECTRAL RESPONSE

DATA MEASURE RESPONSE (CH #~~3~~ 4)

WVLN	REF. SIG.	CH. SIG.	RELATIVE RESPONSE	NORMAL RESPONSE
11.175	4.35mv	742	170	.661
11.200	4.28	715	167	.647
11.225	4.24	683	161	.624
11.250	4.25	637	150	.581
11.275	4.25	579	136	.528
11.300	4.20	507	121	.468
11.350	2.48	347	140	.332
11.400	2.40	174	72.5	.172
11.450	2.50	74	29.6	.070
11.500	2.30	35	15.2	.036
11.600	2.30	5	2.2	.005
11.700	2.30E	2	.87	<.005

TABLE 4.4.3 SH. 2

CHANNEL 3 SPECTRAL RESPONSE

DATA MEASURED RESPONSE (CH ~~#4~~ 3)

WVLN	REF. SIG.	CH. SIG.	RELATIVE RESPONSE	NORMAL RESPONSE
3.400	.490mv	2 mv	∿4	<.004
3.425	.503	4	∿8	.008
3.450	.500	14	27	.014
3.475	.500	33	66	.034
3.500	.495	83	168	.086
3.525	.515	365	709	.364
3.550	.490	767	1565	.804
3.575	.480	871	1815	.932
3.600	.518	974	1880	.965
3.625	.553	1043	1886	.969
3.650	.566	1102	1947	1.000
3.675	.600	1162	1937	.995
3.700	.615	1194	1941	.997
3.725	.640	1214	1897	.974
3.750	.640	1218	1903	.977
3.775	.660	1190	1803	.926
3.800	.660	1208	1830	.940
3.825	.665	1258	1892	.972
3.850	.680	1257	1848	.949
3.875	.686	1237	1803	.926
3.900	.680	1177	1731	.889
3.925	.690	980	1420	.729
3.950	.690	491	711	.365
3.975	.695	145	209	.107
4.000	.678	42	62	.032
4.025	.675	19	28	.014
4.050	.665	12	18	.009
4.075	.658	3	4.6	.002
4.100	.635	3	4.7	.002

TABLE 4.4-4

CHANNEL 4 SPECTRAL RESPONSE

DATA MEASURED RESPONSE (CH #5)

WVLN	REF. SIG.	CH. SIG.	RELATIVE RESPONSE	NORMAL RESPONSE
11.0	4.46mv	1 mv	.224	.0015
11.25	4.41	1	.226	.0015
11.30	4.40	8	1.818	.012
11.35	4.32	40	9.259	.061
11.40	4.23	144	34.04	.226
11.45	4.19	333	79.47	.528
11.50	4.10	488	119.02	.791
11.55	4.02	536	133.33	.886
11.60	3.98	538	135.16	.898
11.65	3.86	552	143.00	.951
11.70	3.71	558	150.40	1.00
11.75	3.60	532	147.78	.983
11.80	3.45	488	141.45	.940
11.85	3.40	458	134.70	.896
11.90	3.30	445	134.85	.897
11.95	3.28	440	134.15	.892
12.00	3.24	433	136.73	.909
12.05	3.21	419	130.53	.868
12.10	3.18	399	125.47	.834
12.15	3.12	373	119.55	.795
12.20	3.08	351	113.96	.758
12.25	3.03	325	107.26	.713
12.30	2.98	307	103.02	.685
12.35	2.95	293	99.32	.660
12.40	2.90	257	88.62	.589
12.45	2.86	151	52.79	.351
12.50	2.80	62	22.14	.147
12.55	2.70	18	6.66	.049
12.60	2.62	8	3.05	.020
12.65	2.50	4	1.60	.011
12.70	2.43	1	.412	.0027
12.90	2.11	1	.474	.003

TABLE 4.4-5

CHANNEL 5 SPECTRAL RESPONSE

SCAN DIRECTION DATA

MICROMETER POSITION	CH 1 mv	CH 2 mv	CH 3 mv	CH 4 mv	CH 5 mv	MICROMETER POSITION	CH 1 mv	CH 2 mv	CH 3 mv	CH 4 mv	CH 5 mv
.600	1.1	3.3	19	35	1.0	.495	134	964	534	2840	175
.595	1.0	3.0	18	40	2.0	.490	135	964	552	2810	169
.590	1.0	4.0	18	44	2.0	.485	135	959	562	2760	157
.585	1.0	4.0	20	48	3.0	.480	134	951	526	2630	143
.580	1.0	5.0	13	53	3.0	.475	132	920	430	2340	130
.575	1.0	1.0	12	60	5.0	.470	118	701	266	1705	112
.570	2.0	6.0	17	69	7.0	.465	67	331	145	890	87
.565	2.0	7.0	19	76	11	.460	25	100	78	260	67
.560	3.0	9.0	25	87	16	.455	13	47	39	105	41
.555	3.0	14	35	124	27	.450	8.0	27	30	86	27
.550	4.0	25	54	285	38	.445	5.0	15	21	71	18
.545	9.0	83	95	725	48	.440	2.0	8.0	16	65	12
.540	30	300	152	1245	70	.435	2.0	6.0	16	59	7.0
.535	67	600	220	1835	103	.430	1.0	5.0	14	52	4.0
.530	112	885	290	2350	166	.425	1.0	4.0	11	48	2.0
.525	134	963	331	2590	202	.420	1.0	4.0	8.0	52	2.0
.520	134	968	376	2780	218	.415	-	-	-	-	-
.515	134	960	403	2870	216	.410	1.0	3.0	3.0	34	3.0
.510	133	966	438	2900	204	.405	-	-	-	-	-
.505	134	965	474	2900	195	.400	1.0	2.0	6.0	22	3.0
.500	134	962	505	2890	185						

DATE 3/21/78 UNIT AVHRR/2 PFM

TABLE 4.5-1

IFOV RESPONSE CONTOUR

CROSS SCAN DIRECTION DATA

MICROMETER POSITION	CH 1 mv	CH 2 mv	CH 3 mv	CH 4 mv	CH 5 mv	MICROMETER POSITION	CH 1 mv	CH 2 mv	CH 3 mv	CH 4 mv	CH 5 mv
.600	1.0	3.0	10	30	1.0	.495	132	924	382	2850	165
.595	1.0	3.0	2.0	43	2.0	.490	130	922	375	2780	156
.590	1.0	3.0	6.0	38	1.0	.485	129	888	354	2590	138
.585	1.0	4.0	10	43	1.0	.480	104	704	331	2320	111
.580	1.0	5.0	8.0	61	1.0	.475	64	495	233	1890	68
.575	2.0	6.0	15	58	3.0	.470	25	250	102	1230	38
.570	2.0	10	11	66	6.0	.465	10	39	55	530	23
.565	3.0	23	19	81	11	.460	7.0	16	25	150	16
.560	6.0	45	27	105	17	.455	4.0	12	19	94	7.0
.555	10	77	46	160	28	.450	2.0	12	18	80	6.0
.550	36	200	109	405	47	.445	-	-	-	-	-
.545	70	468	206	931	70	.440	2.0	10	14	66	4.0
.540	107	775	295	1720	106	.435	-	-	-	-	-
.535	131	935	326	2380	136	.430	1.0	8.0	13	53	2.0
.530	134	945	339	2640	154	.425	-	-	-	-	-
.525	130	930	340	2750	164	.420	1.0	6.0	12	46	2.0
.520	130	928	344	2810	171	.415	-	-	-	-	-
.515	133	937	343	2850	176	.410	1.0	4.0	11	38	1.0
.510	133	944	356	2880	178	.405	-	-	-	-	-
.505	135	943	370	2900	178	.400	1.0	3.0	1.0	35	2.0
.500	135	942	380	2890	177						

DATE 3/21/78 UNIT AVHRR/2 PFM

TABLE 4.5-2

IFOV RESPONSE CONTOUR

IFOV CENTER LOCATION (SCAN DIRECTION)

	CH 1		CH 2		CH 3		CH 4		CH 5	
	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position
Peak Signal	.256		.808		.415		.970		.195	
Upper 50%	.128	.5334	.404	.5312	.207	.5288	.485	.5327	.0975	.5313
Lower 50%	.128	.4630	.404	.4614	.207	.4657	.485	.4632	.0975	.4640
Upper 20%	.0512	.5378	.162	.5360	.083	.5385	.194	.5416	.039	.5418
Lower 20%	.0512	.4590	.162	.4573	.083	.4578	.194	.4573	.039	.4510
IFOV Center		.4982		.4963		.49725		.49795		.49765
IFOV Width 50%		.0704		.0698		.0631		.0695		.0673
IFOV Width 20%		.0788		.0787		.0807		.0843		.0908
20%/50% Ratio		1.12		1.13		1.28		1.21		1.35
IFOV Width (Millirad.)		1.429		1.417		1.281		1.411		1.366

TABLE 4.5-3

IFOV CENTER LOCATION (CROSS SCAN DIRECTION)

	CH 1		CH 2		CH 3		CH 4		CH 5	
	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position	Output Voltage	Micro Position
Peak Signal	.258		.795		.324		.950		.172	
Upper 50%	.129	.5403	.3975	.5398	.162	.5390	.475	.5376	.086	.5352
Lower 50%	.129	.4693	.3975	.4686	.162	.4663	.475	.4674	.086	.4700
Upper 20%	.052	.5448	.159	.5445	.065	.5447	.190	.5460	.034	.5460
Lower 20%	.052	.4660	.159	.4640	.065	.4624	.190	.4605	.034	.4625
IFOV Center		.5048		.5042		.50265		.5025		.5026
IFOV Width 50%		.071		.0712		.0727		.0702		.0652
IFOV Width 20%		.0788		.0805		.0823		.0855		.0835
20%/50% Ratio		1.11		1.13		1.13		1.22		1.28
IFOV Width (Millirad.)		1.441		1.445		1.476		1.425		1.323

TABLE 4.5-4

CHANNEL 1 MTF DATA

TARGET SPATIAL FREQUENCY	SCAN DIRECTION		CROSS SCAN DIRECTION	
	PK-PK VOLTAGE	MTF	PK-PK VOLTAGE	MTF
1 IFOV	1.55	.443	1.5	.441
1.5	2.9	.829	2.9	.853
2.0	3.4	.971	3.3	.97
4.0	3.5	1.0	3.4	1.0
D.C.	3.5	1.0	3.4	1.0

CHANNEL 2 MTF DATA

TARGET SPATIAL FREQUENCY	SCAN DIRECTION		CROSS SCAN DIRECTION	
	PK-PK VOLTAGE	MTF	PK-PK VOLTAGE	MTF
1 IFOV	1.9	.452	1.8	.462
1.5	3.45	.821	3.4	.872
2.0	4.2	1.0	3.85	.987
4.0	4.2	1.0	3.9	1.0
D.C.	4.2	1.0	3.9	1.0

TABLE 4.6-1

CHANNEL 3 MTF DATA

TARGET SPATIAL FREQUENCY	SCAN DIRECTION		CROSS SCAN DIRECTION	
	PK-PK VOLTAGE	MTF	PK-PK VOLTAGE	MTF
1 IFOV	1.95	.487	1.5	.417
1.5	3.5	.875	3.0	.833
2.0	4.0	1.00	3.6	1.0
4.0	4.0	1.00	3.6	1.0
D.C.	4.0	1.00	3.6	1.0

CHANNEL 4 MTF DATA

TARGET SPATIAL FREQUENCY	SCAN DIRECTION		CROSS SCAN DIRECTION	
	PK-PK VOLTAGE	MTF	PK-PK VOLTAGE	MTF
1 IFOV	3.4	.493	3.1	.492
1.5	5.85	.848	5.6	.888
2.0	6.7	.971	6.2	.984
4.0	6.85	.993	6.2	.984
D.C.	6.9	1.0	6.3	1.0

CHANNEL 5 MTF DATA

TARGET SPATIAL FREQUENCY	SCAN DIRECTION		CROSS SCAN DIRECTION	
	PK-PK VOLTAGE	MTF	PK-PK VOLTAGE	MTF
1 IFOV	1.5	.366	1.5	.405
1.5	3.3	.805	3.0	.810
2.0	4.0	.976	3.6	.973
4.0	4.1	1.00	3.7	1.00
D.C.	4.1	1.00	3.7	1.00

TABLE 4.6-2

5.0 MAGNETIC TAPE DATA

5.1 Format - Data

Calibration information is stored on magnetic tapes in 60 line files of data per input scene calibration point. Each data file contains a header as presented in Table 5.1-1. Each magnetic tape is identified by a label. Table 5.1-2 is the format of this label.

AVHRR HEADER DATA FORMAT FOR EACH

MAGNETIC TAPE FILE

CHARACTER	DESCRIPTION	EXAMPLE	SOURCE
1-6	Date of Recording (YYMMDD)	731210	Operator
7-12	Time of Recording (HHMMSS)	142000	Operator
13-16	Digital Tape #	1-9999	Operator
17-18	Test Mode	BT or TV	Operator
19-20	Mag Tape File Number	1 - 10	AVHRX
21-22	Record Mode	0, 1 or 2	DIALOG
23-102	Visible Integrating Sphere Radiance and Units	VI,XXX.XX, MV,YY Bulbs, CHN	Operator
103-134	8 TM's Earth Scene Cal Target	300K	DVM
135-136	VI or IR	VI or IR	Operator
137-138	Instrument in or out of Chamber	IN or OUT	Operator
139-180	21 Binary TM's		Analog TM

TABLE 5.1-1

MAGNETIC TAPE LABELS

PROJ. NAME	MOTOR	ON OFF
MOD. & S/N	ELEC.	ON OFF
DATE:	TLM	ON OFF
TIME:	CHANNEL 1	ON OFF
TAPE #	CHANNEL 2	ON OFF
FILE 3's ____ THRU	CHANNEL 3	ON OFF
____OF____TAPES	CHANNEL 4	ON OFF
DI/SE:	MOTOR	HI LOW
B.P.T.:	VOLT-CAL	ON OFF
CAL. TGT. RGE:	EARTH-SH	ON OFF
IR/VI DATA:	COOLR-HT	ON OFF
TP #	PATCH-HT	HI LOW
**********	PATCH	ON OFF
9 TRACK, 8ØØ BPI		

TABLE 5.1-2

5.2 Magnetic Tape Listing

The following is a list of calibration tapes recorded on the AVHRR/2 PFM:

TAPE NO.					
2010	VIS	CALIBRATION			
2011	VIS	"			
2015	IR	"	10°C	B.P.	TEMP.
2016	"	"	10°C	"	"
2017	"	"	10°C	"	"
2018	"	"	15°C	"	"
2019	"	"	15°C	"	"
2020	"	"	20°C	"	"
2021	"	"	20°C	"	"
2022	"	"	25°C	"	"
2023	"	"	25°C	"	"
2024	"	"	30°C	"	"
2025	"	"	30°C	"	"
2026	"	"	15°C	"	"(Rerun)
2027	"	"	15°C	"	"(Rerun)